

ABSTRACTS

Contributed Papers (Oral and Poster) Colloquia Workshops

91st Annual Meeting of the American Society for Horticultural Science

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The Abstracts that follow are arranged in *numerical* sequence by the abstract number. For Poster Sessions, the number preceded by PB (i.e., PB XXX) indicates the poster board number on which the poster will be mounted.

Abstracts for Oral Sessions, Colloquia, and Workshops are grouped by sessions. To determine when a paper is to be presented, check the session number in the Program Schedule or the Conference at a Glance charts. The author presenting the paper is indicated by an asterisk.

12 ORAL SESSION 1 (Abstr. 001-008) Vegetables: Cover Crops/Culture and Management

001

COLLABORATIVE LEARNING AND PARTICIPATORY ON-FARM RESEARCH: COVER CROPS AND VEGETABLE PRODUCTION SYSTEMS

John M. Luna*, Daniel Green-McGrath, Ray William, Stefan Seiter and Tom Ten as. Department of Horticulture, Oregon State University, Corvallis, OR 97331.

A participatory, on-farm research project was initiated in 1992 in an effort to enhance mutual learning, knowledge, and experience of integrating cover crops into western Oregon vegetable production systems. A major goal of the project was to include growers, agribusiness representatives, governmental agency, Extension and university researchers in a collaborative learning process, emphasizing grower participation in the design and implementation of on-farm research and demonstration projects. To facilitate this participation from the *planning* stage *forward*, four "focus sessions" were hosted by lead farmers in different areas of the Willamette Valley to define growers' needs and

interests relating to on-farm research and demonstration trials.

Based on individual growers' specific experimental objectives, cover crop evaluation trials were established on ten farms. Typically on each farm, 5 to 10 cover crop species or mixtures (grain and legume) were planted in large plot strips. Twenty five different cover crop species, varieties, and mixtures were planted. Seasonal cover crop biomass and nitrogen accumulation rates were determined, with cover crop impacts on crop yields and economic returns evaluated at selected sites.

002

HAIRY VETCH COVER CROP PROVIDES ALL THE NITROGEN REQUIRED BY THE TOMATO CROP

Aref A. Abdul-Baki* and John R. Teasdale, U.S. Department of Agriculture, Agricultural Research Service, Vegetable and Weed Science Laboratories, Beltsville, MD 20705-2350

Nitrogen requirements by fresh-market field tomatoes (*Lycopersicon esculentum* Mill.) were determined on plants grown in a hairy vetch mulch (HVM) or in black polyethylene mulch (BPM). Nitrogen treatments were 0, 56, 112, and 168 kg/ha delivered weekly through the trickle system. Yields in BPM increased significantly with higher applications of nitrogen from 54 to 91 tons/ha and chlorophyll content of fully expanded leaves increased from 7.8 to 11.3 OD₆₆₄ per 100 mg fresh weight. In contrast, neither yield nor chlorophyll content of leaves increased significantly by adding nitrogen. The 0 nitrogen treatment in HVM yielded 89 ton/ha and chlorophyll content was 13.5 OD₆₆₄ making it equivalent to those in BPM that had received 168 kg nitrogen/ha. The results suggest that hairy vetch can provide all the nitrogen required by the subsequent tomato crop and produces high yields and vigorous plants.

003

SYSTEMIC IMPACTS OF NON-CROP RESIDUES ON PEST MANAGEMENT IN SNAP BEAN PRODUCTION.

Ed Peachey* and Ray William, Horticulture Dept., Oregon State University, Corvallis, OR 97341.

Altering the physical or chemical nature of the crop production environment through introduction of cover crops or other non-crop vegetation may amend the impact of various pests on vegetable crops. Current work is focused on the interaction of cereal cover crops and respective management systems with weed emergence and growth, white mold (*Sclerotinia sclerotiorum*) incidence, symphytan (*Scutigerella immaculata*) population dynamics, soil food-web structure, and crop yield in snap bean production systems. Research has

demonstrated the potential of cover crop residues, tillage, and a single broadcast application of a postemergence herbicide to control summer annual weeds. Additionally, white mold incidence was significantly decreased by both reduced tillage conditions and flailed barley cover crop residues in one year of research. Two years of research indicate that symphytan density can be reduced by flailing spring-planted cereals before crop planting.

004

WINTER COVER CROPS FOR WEED CONTROL IN SUSTAINABLE VEGETABLE PRODUCTION

Vasey N. Mwaja* and John B. Masiunas, University of Illinois, 1201 W. Gregory Dr., Urbana, IL 61801

A three-year study determined the effect of winter cover crops on weeds and vegetable crops in a vegetable production system. Winter rye and hairy vetch were interseeded in the fall of 1990, 1991 and 1992 at 112 and 34-kg ha⁻¹, respectively. The cover crops were killed by either applying glyphosate at 1.1 kg a.i ha⁻¹ [reduced tillage(RT)] or mowing and disking the cover crop (Disked). The conventional tillage (CT) was bare ground with a preplant incorporated application of 0.84 kg a.i ha⁻¹ of trifluralin. During the three years, the greatest snap bean yields were in the CT; total yields of cabbage and tomato varied between the years; and were not affected by management systems. Weed control was similar in the RT and CT treatments during the three years. Disked cover crop treatments tended to have greater weed numbers than either RT or CT treatments.

005

EVALUATING VELVETBEAN AS PART OF THE CROP ROTATION IN SUSTAINABLE VEGETABLE PRODUCTION

Kathryn E. Brunson*, Sharad C. Phatak, J. Danny Gay, and Donald R. Sumner, University of Georgia, Tifton, GA.31793

Velvetbean (*Mucuna deeringiana* L.) was used in crop rotation to determine the influence on southern root-knot nematode (*Meloidogyne incognita*) in sustainable vegetable production. Replicated trials were conducted at four locations. Two cover crop treatments, crimson clover and subterranean clover, were used in the sustainable plots and rye was the plow-down cover crop for the conventional plots. Selected as the vegetable crops were tomato, pepper, and eggplant. Following the final harvest, velvetbean was planted into the sustainable plots and disked under after 90 days. Results from soil samples before and after velvetbean, indicated the sustainable plots had substantially reduced nematode densities, while most conventional plots showed increases. A correlation between location, treatment, root-gall indexes and nematode density occurred in all crops for 1992. In 1993 there was only a correlation between root-gall index and nematode density in pepper. However, root-gall indexes were significant for location and treatment in all crops.

006

SOIL NITROGEN MOVEMENT AND SOIL STRENGTH IN VARIOUS VEGETABLE CROPPING SYSTEMS

Juan Carlos Gilsanz*, D. C. Sanders, and G.D. Hoyt, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609.

Rye plus crimson clover cover crops were followed by spring potato and fall snap bean or sorghum or fallow. The soil samples at 15 cm increments to 90 cm were evaluated for nitrate levels after each crop and cover crop. After the cover crops, soil nitrate levels were reduced relative to the fallow area. After the potato, crop soil nitrate levels increased above initial spring levels due a uniform fertilization due to the amount of N applied and short cycle of the crop. Snap beans and sorghum had increased plant stands and reduced soil impedance after fall cover crops. HOW nitrate levels varied with soil depth and time will be discussed.

007

NO-TILL CABBAGE PRODUCTION USING RYE COVER CROPS

Warren Roberts* and Bob Cartwright, Wes Watkins Agricultural Research & Extension Center, Oklahoma State University, Box 128, Lane, Oklahoma 74555

Cabbage (*Brassica oleracea* L. Capitata) was grown for five years with treatments comparing no till and conventional production systems. Each year, raised beds were formed in the fall and selected plots were seeded with rye (*Secale cereale*). The rye was allowed to grow during the winter, and the following spring it was either mowed, killed with herbicide, or allowed to grow indefinitely. Different seeding rates of rye and different fertilizer rates were used. Some plots were mowed and the residue removed from the plots, while certain plots had no rye planted but received the rye residue that was removed from other plots. Rye was also gathered and pulverized, and the liquid extract removed from this suspension was sprayed onto plots. Cabbage was planted into each plot in the spring. The yield of cabbage grown in various rye-covered plots was compared to the yield from bare soil plots and from plots covered with black plastic mulch. In general, the plots covered with the various rye treatments had less yield than did the bare soil plots. Plots covered with black plastic mulch often had a greater yield than did the other plots.

008

COVER CROP MANAGEMENT FOR PROCESSING TOMATO PRODUCTION

Nancy G. Creamer* and Mark. A. Bennett, Department of Horticulture, The Ohio State University, 2001 Fyffe Ct., Columbus, OH 43210.

A mixture of rye, hairy vetch, barley, and crimson clover was seeded on raised beds at two locations in Ohio in August, 1992. The following May, the mixture was killed with an undercutter and left on the surface as a mulch. Processing tomatoes (OH 8245) were planted into the killed cover crop mulch immediately following undercutting. Four systems of production were evaluated including: conventional (without cover crop mulch), integrated (with reduced chemical input), organic, and no additional input. At the Columbus site, above ground biomass (AGB) was 9,465 kg ha⁻¹ with 207 kg ha⁻¹ N in to AGB. In Fremont, the AGB was 14,087 kg ha⁻¹ with 382 kg ha⁻¹ N in the AGB. Annual weeds were suppressed by the killed cover crop mulch, and no additional weed control for the annual weeds was necessary. Weed suppression by the mulch was equivalent to weed suppression by the herbicides used in the conventional system. Other data that will be reported include soil moistures and temperatures; impact on insects and diseases; and, tomato growth, development, and yield.

13 ORAL SESSION 2 (Abstr. 009-016) Berries: Breeding and Genetics

009

GENETIC VARIABILITY IN Highbush BLUEBERRY, VACCINIUM CORYMBOSUM L., FOR RESISTANCE TO THE BLIGHTING PHASE OF MUMMYBERRY, MONILINIA VACCINI-CORYMBOSII

Mark K. Ehlenfeldt*, Vickie Brewster, and Allan W. Stretch, USDA-ARS, Blueberry and Cranberry Research Center, Rutgers University, Penn State Forest Road, Chatsworth, NJ 08019

Potted plants of 53 highbush and half-high blueberry cultivars were screened for resistance to the blighting phase of mummyberry, *Monilinia vaccinii-corymbosii* under controlled nursery conditions over an 18 day infection period. Significant differences were observed in the susceptibility of different cultivars, with 'Bluehaven', 'Bluegold', and 'Blueray' being among the most susceptible, and 'Bluejay', 'Jersey', and 'Duke' being among the most resistant. Differences were also observed in the latent periods and rate of disease progress which may have a bearing on the severity of the secondary fruit infection phase. Preliminary observations suggest that shoot blighting and fruit infection frequencies are not strongly correlated under high inoculum conditions.

BREEDING BLUEBERRIES WITH ALTERED FLOWER ARCHITECTURE

Paul M. Lyrene, Horticultural Sciences Dept., University of Florida, Gainesville, FL 32611.

Genetic variation was surveyed within and among 5 *Vaccinium* species and several hybrid taxa for 6 aspects of flower size and shape. Sufficient variation was found to allow radical changes in flower architecture through breeding. The goal is a flower that pours pollen directly from the anthers onto the stigma without the assistance of pollinating insects. The flowers of *V. elliotii* had very short styles (mean in mm 5.3 compared to 10.2 for rabbiteye cultivars and 8.5 for highbush cultivars), and certain short-style recombinants from highbush cultivar x *V. elliotii* crosses came close to the desired positioning of stigmas relative to anthers. The distance (in mm) from the anther pore to the stigma averaged: *V. ashei* 2.7; *V. corymbosum* 2.4; *V. darrowi* 2.3; and *V. elliotii* 1.0. Compared to highbush cultivars, rabbiteye cultivars tended to have long corollas and narrow corolla apertures, two features believed to be related to poor honeybee pollination. These features were much more favorable in *V. ashei* x *V. constablaei* hybrids, with values averaging close to those for highbush cultivars.

011

RAPD ANALYSIS IDENTIFIES GENETIC VARIATION AND RELATEDNESS WITHIN THE CRANBERRY VARIETY MCFARLIN

Richard Novy¹*, Kim Patten² and Nicholi Vorsa¹, ¹Blueberry and Cranberry Research Center, Rutgers University, Chatsworth, NJ 08019, and ²Washington State University-Long Beach Research and Extension Unit, Long Beach, WA 98631

The cranberry cultivar 'McFarlin', selected from a natural bog in Massachusetts in 1874, has become the most widely grown cultivar in the Northwestern U.S.A. Washington state growers have noted variable productivity among 'McFarlin' bogs. The determination of whether there is a genetic basis for the variability has been made difficult by a paucity of reliable morphological descriptors in cranberry. A random amplified polymorphic DNA (RAPD) analysis of 45 clones sampled from 12 WA 'McFarlin' bogs identified 17 unique RAPD profiles. Cluster analysis identified 7 groups having various numbers of distinct, but related individuals. Eight clones were found to have RAPD profiles identical to the cultivar 'Howes' indicating varietal misclassification had occurred in some bogs. One group of clones that originated from bogs classified as 'Good' or 'True' 'McFarlin' by growers had RAPD profiles similar to those of representatives from WI and MA 'McFarlin' bogs. RAPD analysis has shown that 'McFarlin' is represented by several genotypes, suggesting that the observed variability in production may have a genetic component.

012

EXPLOITATION OF RUBUS STRIGOSUS IN RASPBERRY BREEDING

Hugh A. Daubeney*, Agriculture Canada Research Station, 6660 N.W. Marine Drive, Vancouver, B.C. V6T 1X2

The indigenous North American red raspberry, *Rubus strigosus* has been neglected in breeding programs. Only four cultivars, 'Cuthbert', 'Latham', 'Herbert' and 'Ranere' provide most of the germplasm contained in present-day cultivars; no more than six individual wild genotypes of the species are represented by the four cultivars. In recent years, the B.C. breeding program has screened seedling populations of hitherto unexploited genotypes of the species from various locations in North America. Useful traits identified in selections from the populations include levels of resistance to 1) the North American aphid vector, *Amphorophora agathonica*, of the raspberry mosaic virus complex, 2) to several cane diseases and 3) to root rot caused by *Phytophthora fragariae* var *rubri*, as well as desirable fruit traits, such as bright, non-darkening red color and easy release. Selections with cultivar potential have now been identified in the second and third backcross generations from the species.

013

YEAR-TO-YEAR CONSISTENCY OF HARVEST DATA FROM RED RASPBERRY BREEDING PLOTS

Patrick P. Moore, Washington State University Puyallup Research and Extension Center, Puyallup, WA 98371.

In our breeding program, harvest data is first collected two years after planting. In order to streamline efforts, some selections are discarded after the first harvest season and attention is concentrated on the remaining selections. Some selections that could become potentially superior cultivars that are slow to establish may be discarded. To test how reliable the first year data is for making decisions, the first year harvest data from five plantings was compared with the second

year harvest data. Fruit rot and yield were the least consistent ($r = 0.28$ and 0.36 respectively) while fruit weight ($r=0.76$), fruit firmness ($r=0.63$) and midpoint of harvest ($r=0.79$) were more consistent. The impacts of decisions based on first year harvest data will be discussed.

014

MORPHOLOGICAL AND MOLECULAR VARIATION IN WILD OCTOPOLOID NORTH AMERICAN STRAWBERRY (*FRAGARIA*)

Richard E. Harrison¹, James J. Luby¹ and Glenn R. Furnier^{2,3}, ¹Depts. of Horticultural Science¹, Forest Resources² and Plant Biology³, University of Minnesota, St. Paul, MN 55108

Runners from 318 plants representing 37 populations across the northern tier of US states, from Washington to New York, were collected and planted in two replications in a common greenhouse environment to assess morphological variation among octoploid strawberries (*Fragaria chiloensis*, *F. virginiana* spp. *glauca* and *F. v. virginiana*). DNA was also extracted from these plants to determine molecular variation using RAPD's (Random Amplified Polymorphic DNA). Preliminary data suggest that the following morphological characters are useful traits in assessing diversity: flowering and runnering date; sex; petiole and peduncle hairs; petiole and peduncle color; leaf color, size, shape and density; and powdery mildew resistance. Preliminary RAPD data has revealed many useful molecular markers capable of detecting variability from the intrapopulation to interspecific level. Analysis of these data will determine relative genetic distances among the populations and provide a more complete understanding of the diversity available to the strawberry breeder in the octoploid taxa native to North America.

015

PERFORMANCE OF TWELVE STRAWBERRY GENOTYPES IN FUMIGATED AND NONFUMIGATED SOIL

Kirk D. Larson and Douglas V. Shaw*, Pomology Department, University of California, Davis, CA 95616

Performance traits for twelve strawberry genotypes (*Fragaria* x *ananassa*) were evaluated in annual hill culture, with and without preplant soil fumigation (methyl bromide/ Chloropicrin 67:33, 350#/A) at two locations. One trial followed several cycles of strawberry plantation whereas the other had not been planted to strawberries for over 20 years. Plant mortality was less than 3%, thus the main effects of fumigation treatment in these experiments must be due to sublethal effects of soil organisms. Plants grown in nonfumigated soil yielded 57% and 51% of the fruit produced by plants on adjacent fumigated soil, for "new" and "old" strawberry ground respectively. Highly significant ($P<0.01$) differences were also detected for fruit weight (88% and 93%) and leaf number after plantation establishment (73% and 80%). Significant genotype x fumigation interaction was not detected for any of the Performance traits. These results demonstrate that strawberry productivity is substantially increased by fumigation, even in the absence of lethal pathogens. More importantly, little opportunity exists for developing cultivars specifically adapted to nonfumigated soils.

016

NJUS STRAWBERRY BREEDING ADVANCED SELECTIONS FOR THE ANNUAL AND MATTED-ROW PRODUCTION SYSTEMS

Joseph A. Fiola, Gojko Jelenkovic, and Gene Galletta, Rutgers Fruit R&D Center, Cream Ridge, NJ 08514.

The major objective of the NJUS Strawberry Breeding Program is the development of early ripening cultivars with excellent fruit flavor and size for production under conventional matted-row, and high density annual production systems. In the 1993 replicated Step 3 trials (1991; 1992 planted), sixteen selections had higher yield than 'Earliglow' (8127, 11312 kg/Ha), ranging from 8433 kg/Ha to 13334 kg/Ha. Thirty-one had higher weighted average fruit weight (WAFW) over the season than 'Earliglow' (8.8 g; 8.4 g), ranging from 9.0 g to 12.3 g.

Selection for phenotype best suited for annual stem includes: low runnering, strong vigor, earliness, and large fruit size. In 1993 harvested Step III, four selections had comparable or higher yield (range: 12,866 to 27,128 kg/Ha) than 'Chandler' (12,950 kg/Ha), as well as larger primary and WAFW (range: 13.5 to 16.4 g). All selections were significantly earlier than 'Chandler'. In summary, the NJUS Strawberry Breeding Program has selections for the matted-row and annual production systems which are early, with excellent fruit flavor, size, and firmness for fresh market production.

Floriculture/Foliage: Plant Growth Regulation

017

GROWTH REGULATOR EFFECTS ON HEIGHT CONTROL OF POTTED MUSSAENDA QUEEN SIRIKIT

Christopher S. Cramer¹ and Mark P. Bridgen, Department of Plant Science, University of Connecticut U-67, 1376 Storrs Rd., Storrs, CT 06269, USA.

Mussaenda, a tropical ornamental shrub developed in the Philippines is being examined as a potential greenhouse potted crop in the United States. Showy sepals of white, picotee, pink or red and fragrant, yellow flowers make Mussaenda an attractive potted plant; however, the profuse upright growth habit of some Mussaenda cultivars is undesirable for pot plant culture. With this in mind experiments were conducted to determine the effects of three growth regulators at two concentrations each, as well as the application method and the number of applications on Mussaenda plant height.

Three growth regulators, daminozide (B-Nine), ancymidol (A-Rest), and paclobutrazol (Bonzi) were applied at two commercially recommended rates and two application methods (spray or drench). The treatment were daminozide at 2500 ppm and 5000 ppm (spray), ancymidol at 33 and 66 ppm (spray) and at 0.25 and 0.50 mg/pot (drench), and paclobutrazol at 25 and 50 ppm (spray) and at 0.125 and 0.25 mg/pot (drench). In subsequent experiments, the same growth regulators were applied with an increase in concentration and either two or three applications. The treatments were daminozide at 5000 ppm (spray), ancymidol at 66 and 132 ppm (spray) and at 0.50 and 1.0 mg/pot (drench), and paclobutrazol at 50 and 100 ppm (spray) and at 0.25 and 0.50 mg/pot (drench).

The most attractive potted plants were produced with two applications of daminozide at 5000 ppm or two applications of ancymidol at 0.5 mg/pot (drench). Higher concentrations or additional applications excessively reduced plant height. Three spray applications of 132 ppm ancymidol also produced an attractive potted plant. Paclobutrazol sprays or drenches at any concentration or application number were ineffective for reducing Mussaenda 'Queen Sirikit' plant height.

018

EFFECTS OF ANCYMIDOL, PACLOBUTRAZOL, AND UNICONAZOLE ON GROWTH AND FLOWERING OF *ACHIMENES* cv HILDA UNDER TWO LIGHT LEVELS

J.C. Vlahos*, Technological Educational Institute, 71500 Iraklion, Crete, Greece

Plants of *Achimenes* cv Hilda were treated with foliar sprays of Ancymidol, Paclobutrazol and Uniconazole at 3 different concentrations each, and were placed in a greenhouse at 21°C under 2 light levels (0 and 40% light exclusion) for 12 weeks. Reduced light level decreased plant height, number of axillary shoots and flowers. The three growth retardants in any concentration, suppressed development of axillary shoots and flowers. Ancymidol at 25 and 50 mg.l⁻¹, Uniconazole at 5 mg.l⁻¹ and Paclobutrazol at 25, 50 or 100 mg.l⁻¹ decreased plant height and number of leaf whorls. Number of rhizomes was reduced by the 3 chemicals at the highest concentration only. Paclobutrazol was most effective than the other 2 growth retardants. Effects of treatments were more pronounced under shade rather than in full sunlight. Days to anthesis was not affected by any of the treatments except by Paclobutrazol at 100 mg.l⁻¹. The use of these growth retardants in concentration and mode of application similar to those used in this study is not recommended for "Hilda" as height retardation significantly reduces number of flowers.

019

USE OF PACLOBUTRAZOL TO INCREASE LEAF SIZE AND SALABILITY OF *Epipremnum aureum* 'Golden Pothos' ON TOTEMS

C. A. Conover, University of Florida, Inst. of Food and Agr. Sci., Central Florida Research and Education Center, Apopka, FL 32703

Results of a preliminary experiment using paclobutrazol at 0, 12 or 24 mg a.i./3.6-liter pot indicated that its use could enhance the appearance of pothos, but that some refinement of paclobutrazol rates should be made. Two experiments were conducted to determine the rate of paclobutrazol necessary to increase leaf size and optimize plant quality of pothos on totems in 3.6-liter pots grown under shade cloth providing 50% light penetration. In Experiment 1, rooted pothos cuttings were transplanted around a totem pole in a 3.6-liter pot and each pot was treated with a 250-ml drench of water containing Bonzi™ at 0, 4, 8, 12 or 16 mg a.i. Four mg a.i. of paclobutrazol yielded the most desirable plants, based on average leaf size, vine length and plant grade. Experiment 2 was designed to further refine the paclobutrazol application rate. Rooted cuttings of pothos were transplanted around a totem pole in a 3.6-liter pot and each pot was treated with a 100-ml drench of water containing paclobutrazol at 0, 1.32, 2.64, 3.96, 5.28, 6.60 or 7.92 mg a.i. Paclobutrazol applied at a rate of 5.28 mg a.i./3.6-liter pot optimized plant appearance by increasing leaf size and plant grade.

020

UNICONAZOLE TREATMENT IN PROPAGATION AFFECTS ELONGATION OF CHRYSANTHEMUM CUTTINGS.

Richard Kent Schoellhorn*, James E. Barrett and Terri A. Nell, Department of Environmental Horticulture, University of Florida, Gainesville, FL 32611.

Treatments were cultivar, uniconazole concentrations (0, 2, 4, or 8 ppm), and time between dip and placement under mist (0, 10, or 60 minutes). Unrooted chrysanthemum cuttings of cultivars 'Tara' and 'Boaldi' were dipped in uniconazole solutions for 10 seconds. Data were taken 16 days after treatment. A quadratic relationship was found for the interaction between concentration and cultivar. 'Tara': ($y = 6.7277 - 1.532(x) + 0.119409(x^2)$) and 'Boaldi': ($y = 6.4676 - 0.884(x) + 0.060020(x^2)$). Time had no significant interaction with either cultivar or uniconazole concentration.

In a second study, with uniconazole concentrations and storage time (10 minutes or 12 hours), main effects and the cultivar concentration interaction were significant.

021

RESPONSE OF BEGONIA AND CHRYSANTHEMUM TO PACLOBUTRAZOL RESIDUES ON SURFACES IN SUBIRRIGATION

Ahmed A. Al-Badawy*, James E. Barrett and Terri A. Nell, Environmental Horticulture Dept., University of Florida, Gainesville, FL 32611

To evaluate importance of paclobutrazol residues on surfaces, begonia (*Begonia semperflorens*) cv. Whisky and chrysanthemum (*Dendranthema grandiflora*) cv. Coral Davis plants were grown in flats sprayed with paclobutrazol at 0, 50, 100, 200 and 400 ppm.

For begonia, the plant heights at 2 and 4 weeks after treatments were decreased by 39 to 49% and by 55-69%, respectively. The overall change in height ranged from 2.1 to 4.9 cm compared to 15.3 cm for the control plants.

For chrysanthemum, a reduction in plant height was observed and the overall change in height ranged from 2.9 to 5.6 cm compared to 28.8 cm for the control plants.

Based on these results, there is a potential for paclobutrazol to affect non-target plants when subirrigation is used.

022

GROWTH REGULATOR AND APPLICATION TIME INFLUENCE POINSETTIA BRCT SIZE

James E. Barrett* and Terri A. Nell, Dept. of Environmental Horticulture, Univ. of Florida, Gainesville, FL 32611

'V-14 Glory' poinsettias in 15-cm pots were pinched on 24 Sept. and given long days until 8 Oct. Chemical treatments were paclobutrazol drench, paclobutrazol spray, or daminozide/chlormequat (D/C) spray. Time of application was between 8 Oct. and 12 Nov. Heights ranged between 27 and 31 cm. D/C reduced bract size more than paclobutrazol spray, and for both, later treatments had greater effect. Paclobutrazol drench did not have a significant effect.

A second experiment had two cultivars, 'Freedom' and 'V-14'; three paclobutrazol concentrations, 0.2, 0.3 or 0.4 mg per pot; and three application times, 30 Sept., 14 Oct. or 28 Oct. Treatment on 30 Sept. produced the smallest bracts. The cultivar x concentration interaction was significant with 0.4 mg reducing bract size for 'Freedom' but not 'V-14'. Treatments on 28 Oct. had less effect on height than the other two dates. 'Freedom' were shorter than 'V-14'. and higher concentrations had more effect on 'Freedom' than 'V-14'.

023

USE OF GROWTH REGULATORS TO DELAY FOLIAR CHLOROSIS ON EXCISED EASTER LILY LEAVES.

Susan S. Han, Department of Plant and Soil Sciences, French Hall, University of Massachusetts, Amherst, MA 01003

Yellowing of excised Easter lily leaves was significantly delayed by foliar application of gibberellic acids (GA_3) ≥ 250 mg.l⁻¹ or benzyladenine (BA) ≥ 50 mg.l⁻¹. Rapid development of foliar chlorosis following cold storage was delayed significantly by applying 500 mg.l⁻¹ of GA_3 or BA

before storage. Post-storage treatments were less effective. Development of chlorosis was associated with rapid loss of fresh weight and was not related to the aperture of the stomates. Respiration rate of leaves treated with growth regulators were significantly lower than that of the controls. Differences in the rate of carbohydrate depletion may explain the striking effects of growth regulators on the development of foliar chlorosis.

024

ETHYLENE EFFECTS ON MINIATURE POTTED ROSES

Thea M Edwards*. Terril A. Nell. and James E. Barrett, Environmental Horticulture Department, University of Florida, Gainesville, FL 32611

Increased rates of senescence and ethylene related damage of potted flowering plants have been observed in supermarket produce areas where flowers and climacteric produce are displayed together. Ethylene levels in produce areas were found to average 20 ppb. An open system of clear glass chambers with fiberglass lids was designed to simulate retail supermarket conditions. The chambers were kept in postharvest rooms where light level and temperature could be controlled. In a 3 by 3 by 3 Box-Behnken design, Sunblaze 'Candy' miniature potted roses were exposed to three levels of ethylene, 20, 40, and 80 ppb, for 1, 2, and 4 days. The three light levels used were: 0, 7, and 14 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$. Ethylene damage was based on leaf and bud drop and decreased flower longevity.

15 ORAL SESSION 4 (Abstr. 025-032)

Woody Ornamentals/Landscape: Propagation and Tissue Culture

025

MICROPROPAGATION OF *HESPERALOE PARVIFLORA*

A.M. Richwine*. J. Tipton. and G. Thompson, Department of Plant Science, University of Arizona, Tucson, AZ 85721

Hesperaloe parviflora is a useful xeric landscape plant. Two methods of shoot culture initiation were developed. Shoots were initiated indirectly through the use of callus derived from pieces of young inflorescences. Callus was initiated on modified Murashige and Skoog medium with 4.52 μM 2,4-dichlorophenoxyacetic acid and 2.32 μM kinetin. Callus produced shoots when placed on modified MS medium with 6.0 μM zeatin riboside. Direct initiation of shoots was also accomplished using the bottom four floral buds of young inflorescences. Buds were placed on modified MS media containing either benzylaminopurine or kinetin at 0.1, 1.0, or 10.0 μM or zeatin riboside at 6.0 μM . The most shoots were produced by the medium containing 6.0 μM zeatin riboside. Preliminary results indicate optimum shoot production with 2.0 to 4.0 μM BA or 6.0 μM zeatin riboside. *Hesperaloe parviflora* micro-shoots were rooted on one quarter strength MS medium and *ex vitro*.

026

MICROPROPAGATION OF BUTTERNUT, JUGLANS CINEREA

Paula M. Pijut, USDA Forest Service, North Central Forest Experiment Station, 1992 Folwell Ave., St. Paul, MN 55108

Butternut (*Juglans cinerea* L.), a native hardwood to the northeastern United States, is a valuable species for its wood and edible nuts. Butternut is becoming endangered in its native range as a result of a virulent fungal (perennial canker) pathogen, *Sirococcus clavignenti* - juglandacearum. Micropropagation techniques are being developed to clone disease-resistant specimens. Axillary buds, obtained from 2-3-month old seedlings, were induced to break buds *in vitro* and form a single shoot when cultured on Murashige and Skoog (MS) medium supplemented with 200 mg/l casein hydrolysate, 3% sucrose, and 2 mg/l 6-benzylaminopurine. Roots were initiated on microshoots when cultured on half-strength MS medium containing 100 mg/l casein hydrolysate, 1.5% sucrose, and 0.5 mg/l indole-3-butyric acid for seven days in the dark. Adventitious roots elongated when shoots were placed in the light on the same medium, but with

2% sucrose, and no growth regulators. Rooted plantlets were successfully acclimated *ex vitro*. These results provide a basis for the development of techniques to micropropagate selected, mature, disease-resistant butternut germ plasm.

027

MULTIPLICATION OF ROSE SPECIES *IN VITRO*

Yan Ma*, David H. Byrne, Jing Chen and Amanda Byrne, Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

Several rose species (*Rosa rugosa*, *R. wichuraiana*, *R. setigera*, *R. laevigata*, *R. banksiae*, *R. roxburghii*, *R. odorata* and hybrids) were employed to establish the appropriate nutrient media for shoot multiplication and root initiation of cultured shoots and to describe a procedure for the successful transfer to soil of plants obtained *in vitro*. Cultured shoot tips and lateral buds from different genotypes proliferated multiple shoots on a basal medium (MS salt, vitamins, glycine, sucrose and agar) supplemented with 0mg/l to 6mg/l 6-benzylamino purine (BA) and 0mg/l to 0.5 mg/l naphthalene acetic acid (NAA). Most rose species cultured in a modified MS medium supplemented with 2mg/l BA showed good growth and shoot proliferation. The buds nearest the apex exhibited the slowest rate of bud development. Root development was enhanced and shoot development inhibited by lowering the concentration of MS salts to quarter- and half- strength. With difficult-to-root species, rooting was improved by supplementing the media with auxin or giving them 3-7days of dark treatment.

028

SOMATIC EMBRYOGENESIS IN QUERCUS SPECIES

Sudeep Vyapari and Houchang Khatamian, Department of Horticulture, Forestry and Recreation Resources, Kansas State University, Manhattan, KS 66506-4002

Somatic embryogenesis was successfully achieved in chinkapin oak (*Quercus muehlenbergii* Engelm.) and pin oak (*Quercus palustris* Muenchh.) when surface disinfested zygotic embryo explants were cultured on MS or WPM containing BA or kinetin (1.0 or 2.0 mg l⁻¹) plus IBA (1.0 mg l⁻¹). Immature embryos resulted in greater callus induction than the mature ones. Two weeks of dark, proved to be superior to 4 weeks or no dark in callus induction. Somatic embryos of pin oak distinctly showed globular, heart and cotyledonary stages.

Maturation and germination of pin oak somatic embryos was done in growth regulator free WPM by increasing levels of agar (7 - 15 g l⁻¹). Somatic embryos cultured at various levels of agar were then maintained in incubator under standard conditions, desiccated by air-drying or subjected to chilling temperature for 4 weeks to enhance germination of somatic embryos. Root or shoot formation was observed in some cultures, and medium with 9 g l⁻¹ agar induced plantlet production in 7% of the cultures.

029

COMPARISON OF ADVENTITIOUS REGENERATION SCHEMES IN WHITE ASH

Sharon A. Bates*, John E. Preece. and John H. Yopp, Departments of Plant and Soil Science and Plant Biology, Southern Illinois University, Carbondale, IL 62901-4415

White ash has been adventitiously regenerated via organogenesis, somatic embryogenesis, and nodule culture. Explant source genotype, plant growth regulator type and concentration affected the type and/or frequency of regeneration observed. Organogenesis was obtained only when thidiazuron was added to the medium and nodules formed only in liquid culture after exposure to BA. Somatic embryos formed when explants were exposed to 2,4-D regardless of cytokinin used. Although large numbers of somatic embryos and nodules may be obtained through liquid suspension cultures, few plantlets were recovered compared to shoot organogenesis. Elongated adventitious shoots elongated and epicotyls from germinated somatic embryos rooted easily *in vitro* or under intermittent mist and were then acclimatized to the greenhouse and planted in the field.

GENOTYPIC AND PHENOTYPIC FIELD GROWTH CORRELATIONS OF MICROPROPAGATED SILVER MAPLE

John E. Preece*, Carl A. Huetteman, W. Clark Ashby, Paul L. Roth and Richard G. Adams, Departments of Plant and Soil Science, Plant Biology, and Forestry, Southern Illinois University, Carbondale, IL 62901-4415

Sixty clones (four clones from each of 15 provenances) were micropropagated and planted in replicated plots in lowland and upland sites in Carbondale, IL in 1991. Data were collected on tree growth, including basal caliper, height, branching, crown volume, dates of bud break, bud set, and leaf fall. There were significant and strong positive genotypic and phenotypic correlations between tree height and basal caliper throughout the three years of growth. During 1993, bud break was not significantly correlated with any growth parameters. After three years in the field, tree height was significantly negatively correlated with the amount of callus that had formed after one month during the in vitro micropropagation phase. However, all shoots that formed in vitro were of axillary origin.

031

EFFECT OF BLANCHING, IBA CONCENTRATION, AND PLANT GROWTH REGULATORS ON GROWTH AND OVERWINTER SURVIVAL OF CUTTING-PROPAGATED ORNAMENTALS

Anna Perkins Nina Bassuk* 20 Plant Science, Cornell University, Ithaca, NY 14853

Budbreak inhibition and poor overwinter survival (OS) limit successful cutting propagation of *Acer rubrum* 'October Glory', *A. rubrum* 'Red Sunset', *Hamamelis vernalis*, *H. virginiana* and *Stewartia pseudocamellia*. Localized blanching (banding) of the cutting on the stock plant; a range of 3 IBA concentrations, and foliar spray application of: 1% silver thiosulfate(STS), STS followed ten days later by Gibberellin, GA₄₇:250ppm(STS GA), 50ppm thidiazuron (TDZ) and TDZ followed by GA₄₇ (TDZ GA) were tested for increasing growth and overwinter survival. Carbohydrates were analyzed in cuttings which did and didn't grow. *A. rubrum* 'October Glory', and *Hamamelis* spp all had increased OS for cuttings which grew. *A. rubrum* 'Red Sunset' demonstrated a similar trend. *Hamamelis* spp. had significant increase in carbohydrates for cuttings which grew. *A. rubrum* 'October Glory' exhibited the same trend. *S. pseudocamellia* did not have increased OS with growth, and showed no increases in carbohydrates with growth, but the cuttings that didn't grow had at least 93 % more carbohydrates than the other species analyzed. All species had higher OS when stored in the 3° C cooler, than in the fluctuating cold frame. Banding increased growth of *A. rubrum* 'October Glory', and *H. virginiana*. IBA concentration affected growth of all species. STS increased growth of *H. virginiana* and *S. pseudocamellia*. GA₄₇ increased growth of all cuttings except *A. rubrum* 'October Glory'.

032

EFFECT OF STRATIFICATION AND GIBBERELLIC ACID ON SEED GERMINATION OF NATIVE PLANTS.

Julia L. Bohnen* and Anne M. Hanchek, Dept. of Horticultural Science, St. Paul, MN 55108.

The Legislative Commission on Minnesota's Resources funded a two year research project to promote expansion of the native wildflower and grass seed industry in Minnesota. Production of seeds and plants for landscaping and restoration is a growing sector of the horticultural industry, yet documentation of production techniques is sketchy due in part to the large number of species. The species *Lilium philadelphicum* (wood lily), *Phlox pilosa* (prairie phlox), and *Spartina pectinata* (prairie cordgrass) were selected for further analysis of germination requirements. These species were noted by producers as having poor and/or unreliable germination. Cold moist stratification and gibberellic acid (GA) treatments were applied. Total percent germination and mean days to germination were calculated and analyzed after 30 days under greenhouse growing conditions. Stratification improved total percent and mean days to germination in *L. philadelphicum*. *P. pilosa* responded to treatment by both stratification and GA. Four weeks of stratification may be the best method for decreasing mean days to germination while obtaining adequate total percent germination for *S. pectinata*.

16 ORAL SESSION 5 (Abstr. 033-439) Fruits/Nuts: Breeding and Genetics

033

INHERITANCE OF THE BLOOD FLESH TRAIT IN PEACH AND INTERACTION WITH THE RED LEAF (GR) GENE.

Michael A. Creller*, Jose X. Chaparro, and Dennis J. Werner, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Inheritance of the blood flesh (red-violet mesocarp) trait in peach [*Prunus persica* (L.) Batsch] was investigated. 'Harrow Blood' fruit began accumulation of anthocyanin about 40 days after anthesis. The blood-fleshed trait was associated with the red-veined leaf phenotype in 'Harrow Blood' and its self progeny. An approximate segregation ratio of 3:1 (red vein:green vein) was observed in a population generated by selfing 'Harrow Blood'. All 112 F₁ progeny from a cross of 'Harrow Blood' x 'Rutgers Red Leaf'-2n produced wild-type fruit. Phenotypic segregation for red leaf:green leaf deviated from the expected 3:1 ratio in two of three F₂ families derived from these F₁'s. More red leaf segregants were observed than expected. Red-veined, green-leafed progeny comprised about 25% of the green-leafed seedlings in the F₂. Examination of fruit on a limited number of F₂ segregants revealed the presence of red-leafed, blood-fleshed individual. Preliminary results suggest that the blood trait may be controlled by two loci. The red-vein phenotype was associated with reduced tree height in self progeny of 'Harrow Blood'.

034

INCORPORATION OF USEFUL TRAITS FROM NATIVE ALMOND SPECIES INTO CULTIVATED ALMOND VARIETIES.

1. HISTORY OF PROJECT.

Dale E. Kester* and Thomas M. Gradziel, Department of Pomology, University of California, Davis, CA 95616

Approximately twenty native almond species have been described. Representative germplasm from seven of these are present in UC collections and have been used in crossing. Three specific breeding lines utilizing these species are described. One (1980 series) involved increasing yield potential through selection of high blossom density following gene introgression from *Prunus fenzi*ana. A second involved incorporation of self-fertility, late bloom, smaller tree size, early maturity, high blossom density, and desirable nut characters from *Prunus webbii* into commercial breeding lines. A self-fertile selection resembling 'Nonpareil' has been obtained from this material. The third line involves transmission of a unique thin, netted-surfaced, hard-shell phenotype from *Prunus argentea*.

035

Disease reactions of apple genotypes to several bitter rot pathogens Y. Shi*, C. Rom*, and J.C. Correll*, Department of Horticulture and Plant Pathology², University of Arkansas, Fayetteville, AR 72701

Disease reactions of 11 apple genotypes (Braeburn, Empire, Gala, Granny Smith, Golden Delicious, Jonathan, Jonagold, McIntosh, Red Delicious, Red Rome and Spartan) to 3 genetically distinct bitter rot pathogens (*Colletotrichum gloeosporioides* [teleomorph (T) and nonteleomorph (NT)] and *C. acutatum*) were examined. Fruit were surface sterilized, and then inoculated either by placing a 100 ul spore suspension (2x10⁷ spores/ml) into wounds or spraying the inoculum onto unwounded fruit. Inoculated fruit were incubated at 26C and 100% RH. Disease reactions were quantified by measuring lesion diameter and depth in wounded fruit, or counting the number of lesions on unwounded fruit. There was a significant interaction between apple genotypes and all 3 pathogenic isolates. The T isolate was the most virulent on all genotypes. In general, cultivars with the smallest lesions in the wound test had the fewest lesions in the unwounded test. Lesion number and size were significantly lower on Granny Smith, Jonagold, Jonathan, Red Delicious and Red Rome. Of the genotypes tested, Braeburn, Gala and McIntosh apparently were the most susceptible.

036

INHERITANCE AND RAPID SCREENING FOR RESISTANCE TO EASTERN FILBERT BLIGHT

Clare J. Coyne* and Shawn A. Mehlenbacher, Dept. of Horticulture, 4017 ALS, Oregon State University, Corvallis, OR 97331

U.S. hazelnut production, concentrated in Oregon, is threatened by eastern filbert blight and all currently grown cultivars are susceptible. Resistant cultivars offer the best control method. Field screening for resistance takes 2 years for symptom expression. The goal of this study was to develop a rapid and reliable screen; to confirm that resistance in 'Gasaway' is conferred by a single dominant gene; and to investigate inheritance in seedlings of the resistant cultivar 'Gem'. Nine controlled crosses made in 1987 and 1988 were screened in the greenhouse in 1992 and 1993. Three trees of each genotype were inoculated and scored for presence or absence of the fungus using either stained tissue sections or ELISA within 6 to 12 months. Progenies of 'Vancouver Resistant' parents (resistant progeny of 'Gasaway') segregated 1 resistant: 1 susceptible and from resistant x resistant parents segregated 3 resistant:1 susceptible in agreement with the single gene hypothesis. Seedlings of 'Gem' were all susceptible.

037

EVALUATION OF XYLELLA FASTIDIOSA IN PRUNUS SPP.

J.D Norton, B.R. Abrahams, G. E. Boyhan, Hongwen Huang, Dept. of Horticulture and Alabama Agricultural Experiment Station, 101 Funchess Hall, Auburn University, AL 36849-5408

Forty eight cultivars, species, and their progeny including *Prunus americana* P. angustifolia, P. cerasifera P. munsoniana, P. salicina, P. simoni, and P. triflora were evaluated for resistance to *Xylella fastidiosa* based on percent of scalded leaves and tree longevity. Observations indicate that resistance is heritable and controlled by recessive genes. Further, X. fastidiosa transmission was evaluated in plum and peach by chip and slip budding. Transmission as measured by enzyme-linked immunoabsorbant assay indicated that chip budding resulted in a higher level of transmission over slip budding in plum but not in peach. Neither Lovell nor Nemaguard rootstock had an effect on transmission.

038

COLLECTION OF WILD MALUS, VITIS, AND OTHER FRUIT SPECIES GENETIC RESOURCES IN KAZAKHSTAN AND NEIGHBORING REPUBLICS

Philip L. Forsline* USDA/ARS, PGRU, Cornell Univ., Geneva, NY, 14456; E.E Dickson, L.H. Bailey Hortorium, Cornell Univ., Ithaca, NY 14850 and A.D. Djangaliev, Kazakhstan Academy of Sciences, 187 Tulabaev St. Apt 11, Almaty 480064, Kazakhstan

The USDA National Plant Germplasm System (NPGS) sponsored a 1993 collection of wild *Malus* in Kazakhstan and Kyrgyzstan which followed a collection in 1989 from sites in Tajikistan and Uzbekistan. There is strong evidence that the domestic apple originated in the foothills of the Tian Shari mountains where *Malus sieversii* (Ldb.) M. Roem remains as a primary forest species. The goal of the recent expedition was to obtain additional genetic diversity of apple from some of the remote sites in that area with the assistance of the Kazakh hosts. While there, isolated pockets of other fruit in the wild (especially *Vitis*) were discovered and collected. Seed collections from the expedition are stored with the NPGS and seedling populations are being evaluated for valuable traits.

039

INTERSTOCK PRESERVATION OF PLANT GERMPLASM

Chenq-chu Nee, Dept. of Horticulture National Chung-Hsing University, Taichung, Taiwan, R.O.C.

The purpose of this invention is to preserve the germplasm which are compatibly graftable for each other in the specific environment. The preserved [interstock] is protected by the rootstock which is used to the stresses from underground, and the "topstock" which is tolerant to the stresses from aboveground.

The compound plant (Top-interstock-rootstock) is different from the traditional combinations which the interstock improve the incompatibility between scion and rootstock. The interstock in this design must

be compatible with its top and rootstock parts and keep "paradormancy" in the germplasm repository.

Preservation of pear species & cultivars will be presented to describe the details of the technique.

24

ORAL SESSION 6 (Abstr. 040-046) Cross-commodity: Cell and Tissue Culture

040

EFFECT OF VARIOUS HORMONES ON THE GROWTH AND GERMINATION OF WALNUT SOMATIC EMBRYOS

Ellen G. Sutter* and Hamid Ahmadi, Department of Pomology, University of California, Davis, CA 95616.

Somatic embryos of *Juglans regia* transformed with *Agrobacterium rhizogenes* Rol B gene and non-transgenic lines were proliferated on basal DKW medium. They were then transferred to media containing different concentrations of ABA, IBA and BA to increase the rate of proliferation and maturation. Transgenic embryos required 50 µM ABA and 40 µM IBA whereas non-transgenic embryos required 40µM ABA and 10 µM IBA. Neither kind of embryos required BA. Roots were induced by drying embryos at 75% for 2-3 weeks until they lost about 30% fresh weight and then transferring them to basal DKW medium for an additional 2 weeks in the dark. Over 50% of the somatic embryos grown on medium containing both ABA and IBA developed well defined root systems compared to less than 15% of embryos grown on basal medium. A combination of 27 µM GA, and 9 µM BA was needed for development of shoot systems and germination of both transgenic and non-transgenic rooted embryos. Anatomical studies followed to characterize the extent of development at each stage.

041

OPTIMIZATION OF ULMUS SUSPENSION CULTURES FOR ELICITOR/PHYTOALEXIN EXPERIMENTS

V.M. Gingas*, S.C. Domir², and J.C. Kamalay¹

¹USDA-Forest Service, Northeastern Forest Experimental Station, Forest Science Lab, Delaware, OH 43015

²USDA-ARS, Ohio Research Site, USDA, Delaware, OH 43015
Suspension cultures of five elm selections (*U. americana* A, 680, 8630 and Del 2 and *U. pumila* S) exhibiting a range of susceptibility responses to the Dutch Elm Disease fungus (*Ophiostoma ulmi*) have been successfully established for future elicitor/phytoalexin studies. Calli initiated from foliar tissues of mature, greenhouse-grown trees cultured on a solid modified MS medium containing 2,4-D and BA were adapted to a liquid modified MS medium containing BA and either IAA or NAA. Cells were grown in either the presence or absence of light with continuous agitation. Uniform, rapidly dividing cell cultures were achieved when friable white or tan calli were grown in the medium containing 1 mg/l each NAA and BA in darkness. Cultures yielding an abundance of phenolic compounds exhibited decreased cell uniformity and proliferation. Increased phenolic production was associated with the presence of phenolics in the initial callus tissue, exposure to light and the use of IAA as the auxin source.

042

EFFECTS OF VESSEL TYPE AND SUBCULTURE DURATION ON IN VITRO MULTIPLICATION OF PONTEDERIA CORDATA L.

Cynthia Zurinsky*, Michael E. Kane and Nancy Philman, Environmental Horticulture Department, University of Florida, Gainesville, FL 32611-0670

Studies were completed to optimize Stage II production efficiency of *Pontederia cordata*, a native wetland plant. Basal shoot tips from established cultures were subcultured into 60 ml glass culture tubes, 155 ml glass baby food jars, 350 ml GA7 polypropylene vessels or 500 ml clear polypropylene tissue culture containers containing full strength Linsmaier and Skoog mineral salts and organics supplemented with 3.0% sucrose, 2.0 mg/liter benzyladenine, 1.0 mg/liter indole-3-acetic acid, 50 mg/liter citric and ascorbic acids solidified with 8 g/liter TC@ agar. Shoot tip to medium volume (ml) ratio was maintained 1:10 in

each culture vessel. Vessel type had no significant effect on either shoot quality or multiplication rate (9.5 shoots/shoot tip/28 days). A maximum production efficiency of 1216 shoots/ft²/28 days was achieved using GA7 vessels. Stage II shoot multiplication rate significantly decreased when the interval between subculture exceeded 28 days.

043

IMPROVING THE MICROPROPAGATION OF *PISTACIA VERA* L.: EFFECTS OF AUXIN, TEMPERATURE, AND METHYL JASMONATE
Elisabet Claveria and Ramon Dolcet-Sanjuan*, Departament de Genètica Vegetal, IRTA, Centre de Cabriels, 08348 Cabriels (Barcelona), Spain

Micropropagation of *Pistacia vera* L. 'Mateur' was improved with the addition of methyl jasmonate (MeJA) to the multiplication and rooting media. Shoot tip cultures established from grafted trees were maintained on a modified Murashige and Skoog medium containing 5 µM BA and 0.05 µM IBA. Addition of 1 µM MeJA improved the multiplication rate but inhibited shoot growth when present at higher concentrations. Rooting experiments comparing the effects of IAA, NAA, or IBA at 0, 1, 3.2, 10, or 31.6 µM demonstrated a significant effect of temperature on auxin root induction for shoots maintained at 25 or 28°C. At 25°C NAA was better than IAA or IBA, whereas no differences among auxins were observed at 28°C. Addition of MeJA (0, 0.3, 1, 3.2, or 10 µM) to the best rooting media significantly improved the rooting percentage and root number. Greater than 80% rooting was obtained when 1 µM MeJA was added to both the root induction medium, containing 31.6 µM NAA, and the auxin-free medium. In addition, transfer to soil and acclimation was easier for plantlets rooted in MeJA-containing medium.

044

VARIETAL DIFFERENCES IN EARLY *EX VITRO* GROWTH AND DEVELOPMENT OF MICROPROPAGATED *PONTERDERIA CORDATA* L.

Myrna Stenberg*, Michael E. Kane and Nancy Philman. Environmental Horticulture Department, University of Florida, Gainesville, FL 32611-0670

Micropropagation is a commercially viable and ecologically sound method for producing native herbaceous wetland plants used for wetland revegetation projects. The ability to rapidly screen, select and store germplasm of wetland species genotypes with desirable characteristics of growth rate and habit, nutrient uptake capacity, and/or substrate preference would significantly impact how micropropagated wetland plants are marketed. Early screening of plantlet growth *ex vitro* may provide an efficient method to select for specific characteristics of growth rate and habit. Five micropropagated lines of *Pontederia cordata* of differing phenotype were established *in vitro* from Florida populations. Rooted microcuttings were established *ex vitro* in a shallow outdoor tank. Growth and development were monitored over a 9 week period. Significant differences in shoot growth and number, leaf area and number, flowering and dry weights were observed between the different *Pontederia cordata* varieties.

045

ANTIBIOTIC SUSCEPTIBILITY OF PLANT-ASSOCIATED BACTERIA
Patricia M. Buckley* and Barbara M. Reed USDA/ARS National Clonal Germplasm Repository, 33447 Peoria Road, Corvallis, OR 97333-2521

Most bacteria isolated from persistently contaminated micropropagated mint plants were Gram-negative rods identified as xanthomonads, pseudomonads, and agrobacteria based on their cultural characteristics. A few Gram-positive, non-sporeforming bacteria were also found. Inhibition of bacterial growth by gentamicin and streptomycin was greater at pH 6.5 and pH 7.5 than at pH 5.5. Inhibition by rifampicin and Timentin was less affected by pH change. Pseudomonads were uniformly resistant to Timentin at all pH's and at levels up to 1000 µg/ml. Streptomycin at 500 µg/ml was bactericidal for the pseudomonads and Gram-positive bacteria while 1000 µg/ml was required to kill xanthomonads and agrobacteria. Minimal bactericidal concentrations for gentamicin varied widely, even within groups, and ranged from 10 µg/ml to >80 µg/ml for agrobacteria. These results emphasize a need to acquire basic information about the identities and antibiotic susceptibilities of microbial contaminants before attempting treatment of infected plant cultures.

046

COMPARATIVE GROWTH RESPONSES AND COSTS UTILIZING TRADITIONAL AND AUTOMATED TISSUE CULTURE SYSTEMS
Brent Tisserat, USDA-ARS, Fruit and Vegetable Chemistry Laboratory, 263 South Chester Avenue, Pasadena, CA 91106

Comparative tests were conducted to determine the influence of the culture vessel size and medium volume on the growth rates of shoot tips of peas (*Pisum sativum* cv. 'Wando'), lettuce (*Lactuca salvia*) Kidney beans (*Phaseolus vulgaris*). Culture vessels employed included: culture tubes, baby food jars, Magenta rectangular containers, 1 -pint Mason jars, 1 -quart Mason jars, 1-quart Mason jars employed with an automated plant culture system (APCS), 1/2-gallon Mason jars with an APCS, BioSafe containers with an APCS, and mega-culture chambers with an APCS. The APCS consisted of a peristaltic pump, media reservoir containing 1 liter of nutrient medium, and a culture chamber (<925 mm³). High positive correlations occurred comparing culture weight, leaf length and plant height with culture chamber volume, media volume and culture chamber height. APCSs consistently gave higher growth rates and exhibition of mature morphogenetic responses such as flowering and fruiting than growing plants on agar culture systems. Cost analysis comparing APCSs and conventional tissue culture systems is presented.

25 ORAL SESSION 7 (Abstr. 047-053) Floriculture: Breeding and Genetics

047

CHROMOSOME ANALYSIS IN *ALSTROEMERIA* SPECIES AND CULTIVARS

Janice L. Stephens* and Harrison G. Hughes, Department of Horticulture, Colorado State University, Ft. Collins, CO 80523

Alstroemeria is an important cut flower in the U.S. due to their wide variety of colors and to their long vase life. The most commonly grown cultivars were developed in Europe and their parentage has never been fully divulged. We are attempting to determine the probable parents of many of these cultivars through karyotype analysis and giemsa banding. Although preliminary karyotype analyses are available for 10 species and 25 cultivars, detailed karyotype analyses of only *A. pelegria* and *A. ligtu* hybrids have been completed. Detailed karyotype analyses are now complete for 7 more species of *Alstroemeria* as well as the related genera *Leontochir* and *Bomarea* and 23 cultivars. A comparison among species and cultivars will be presented reflecting probable parentage of the cultivars. Results of giemsa banding will also be presented to further clarify cultivar parentage and relationships. This information should facilitate the more rapid development of successful cultivars by breeders in the U.S.

048

FERTILITY RESTORATION OF AN INTERSPECIFIC *ALSTROEMERIA* HYBRID BY GENETIC MANIPULATIONS *IN VITRO*
Chunsheng Lu* and Mark Bridgen, Department of Plant Science, U-67, The University of Connecticut, Storrs, CT 96269

An interspecific hybrid of *Alstroemeria aurea* x *Alstroemeria caryophyllaea* was rescued by immature ovule culture and was completely sterile. To restore the fertility of the hybrid, young, vigorous shoots and buds were treated aseptically with three colchicine levels (0.2, 0.4, and 0.6% in DMSO solution) at four treatment durations (6, 12, 18, and 24 hours), before being cultured onto a shoot regeneration medium for regrowth and development. The growth and development of all treated shoots were retarded by the colchicine. New shoots were regenerated from 61% of the surviving cultures after one month. The degree of recovery was not significantly different among treatments, although the highest concentration (0.6%) and the longest time treatment (24 hours) resulted in some morphological abnormalities. Cultures with newly regenerated shoots/buds were able to initiate roots and, eventually, sixty plantlets were transplanted into the greenhouse after acclimatization. Cytological examination of the root tip cells of the plantlets indicated that tetraploids (2n=4x=32) as well as aneuploids plants were generated from the colchicine treatment, whereas all plants from the control were diploids (2n=2x=16). Details explaining cytological changes and the fertility of the colchiploids will be presented.

LONG-TERM GENETIC IMPROVEMENT OF CUT-FLOWER YIELD IN GERBERA

Hongzhan Huang*, James Harding and Thomas Byrne, Department of Environmental Horticulture, University of California, Davis, CA 95616

The effects of long-term genetic improvement are measured by selection response predicted from estimates of narrow-sense heritability. However, changes of population mean must be partitioned into genetic and environmental components -in order to accurately estimate selection response.

A long-term selection experiment for cut-flower yield in the Davis population of gerbera (*Gerbera hybrida*, *Compositae*) was conducted for sixteen generations. Breeding value was estimated for individual plants in the population using Best Linear Unbiased Prediction (BLUP). Genetic change was calculated from breeding values of individual plants in each generation. The results of this study indicate: the long-term selection experiment was successful and necessary for genetic improvement. Genetic change over sixteen generations was 33 flowers. Mean breeding values increased monotonously with an "S" shape pattern. Environmental effects fluctuated from generation to generation. Cut-flower yield in the Davis population of gerbera will continuously respond to selection.

050

Complex Segregation Analysis (CSA) of Gerbera Flower Color

Kenneth R. Tourjee*, James Harding & Thomas G. Byrne
Dept. Env. Horticulture, University of California., Davis, CA 95616

The frequency distribution of gerbera flower hue in the Davis Population of Gerbera appears continuous and bimodal. This suggests that a gene of large effect may be segregating in a background of polygenic variation. CSA is a statistical technique developed in genetic epidemiology for investigating such complex traits, without the need of inbred lines. The REGC program of SAGE (Elston, LSU Med. Center, New Orleans) utilizes the regressive models of G. Bonney (1984) through pedigree analysis to provide estimates of major gene parameters and residual correlations among relatives. Pedigrees obtained from generations 14, 15, and 16 indicate that a major dominant gene for hue is segregating and accounting for ~ 0.66 of the total variation. The genotypic means are 32 degrees and 71 degrees for the aa and bb genotypes, respectively. The 'a' allele is dominant to the 'b' allele and has a frequency of 0.55. The residual parent-offspring correlation estimate is 0.2, and measures the genetic contribution to the remainder of the variance.

051

GENETIC ANALYSIS OF POSTHARVEST LONGEVITY IN *ANTIRRHINUM MAJUS* L.

Susan M. Stieve* and Dennis P. Stimart Department of Horticulture, University of Wisconsin, 1575 Linden Dr, Madison, WI 53706-1590

Selecting for increased postharvest longevity through use of natural variation is being investigated in *Antirrhinum majus* (snapdragon) in order to decrease postharvest chemical treatments for cut flowers. The postharvest longevity of eighteen white commercial inbreds was evaluated. Twelve stems of each inbred were cut to 40 cm and placed in distilled water. Stems were discarded when 50% of spike florets wilted or browned. Postharvest longevity ranged from 3.0 (Inbred 1) to 16.3 (Inbred 18) days. Crossing Inbred 18 x Inbred 1 yields commercially used Hybrid 1 (6.6 days postharvest). The F₂ population averaged 9.1 days postharvest (range 1 to 21 days). F₂ plants indicate short life postharvest may be conferred by a recessive gene in this germplasm. Populations for generation means analysis as well as hybrids between short, medium and long-lived inbreds were generated and evaluated for postharvest longevity.

052

GENETICS OF FLORAL LONGEVITY IN PETUNIA

Kimberly H. Krah* and William M. Randle,
Department of Horticulture, University of Georgia, Athens, GA 30602

Ornamental plant breeding has focused almost exclusively on floral prolificacy rather than floral longevity. The importance of floral longevity is obvious in any ornamental crop grown primarily for floral display. This study was undertaken to determine the genetic basis of floral longevity in

an important ornamental crop, petunia.

Four parental lines representing the extremes for floral longevity were used to generate 6 F₁ families which were selfed to generate F₂ families and backcrossed to create 12 backcross families. Generation means analysis was utilized to determine estimates of additive, dominance, and epistatic genetic variance for floral longevity in petunia.

053

CLONAL DECLINE IN HORTICULTURAL CROPS DUE TO MULLER'S RATCHET

Neil O. Anderson* and Peter D. Ascher, Department of Horticultural Science, University of Minnesota, St. Paul, MN 55108

It should be possible to maintain horticultural clones unchanged forever through asexual generations, as commercial propagators and clonal repositories maintain clonal integrity, disease-free stock plants, or remove mutations. However, unintentional selection for nonhorticultural traits could still be occurring. Accumulations of such traits would be due to the operation of Muller's ratchet and include fertility losses, increases in virus titer, and stunted growth habit. In chrysanthemums, *Dendranthema grandiflora*, clones separated from sexual cycles for generations become increasingly sterile. Seed set across years, using coefficients of crossability (FCC/MCC), was examined for garden clones (forced through sexual cycles annually) and greenhouse clones (asexual cycles only). Garden clones 40 years old (54-101-11) had only depressed levels of fertility. In other cases (77-AM3-17), the ratchet was reversed >1 sexual cycle. Greenhouse clones were often completely sterile since their propagation is primarily asexual.

26

ORAL SESSION 8 (Abstr. 054-059) Berries: Nutrition

054

RESPONSE OF STRAWBERRY TO N FERTILIZATION BY DRIP IRRIGATION

George J. Hochmuth, Earl E. Albregts, and Craig K. Chandler, Horticultural Sciences Department, PO Box 110690, University of Florida, Gainesville, FL 32611-0690

During the 1992-93 fruiting season, strawberries were fertigated weekly with 0.28, 0.56, 0.84, 1.12, or 1.40 kg N/ha/day from ammonium nitrate. K was applied uniformly at 0.84 kg/ha/day by fertigation. Irrigation maintained soil moisture tension in the beds between -10 and -15 kPa. Fruit yields responded positively to N fertilization with yields maximized at 0.56 kg N/ha/day. Leaf N and petiole sap nitrate N concentrations increased with N rate with leaf-N for the plants receiving 0.28 kg N/ha/day remaining below 25 g·kg⁻¹ most of the season. Sufficiency ranges for petiole sap nitrate-N quick testing were developed.

055

FRUITING RESPONSE OF STRAWBERRY IS AFFECTED BY K RATES

Earl E. Albregts*, George J. Hochmuth and C. K. Chandler, Univ. Of Florida Gulf Coast Research and Education Center I.3138 Lewis Gallagher Rd., Dover, FL 33527

During the 1992-93 fruiting season, strawberry plants were fertigated weekly with either 0.28, 0.56, 0.84, 1.12, or 1.40 kg/ha/day of K derived from KCl. Other nutrients were applied in the plant bed before fumigation except for N which was applied at 0.84 kg/ha/day by fertigation. Soil moisture in the plant beds was maintained between 10 and 15 cbs. Initial soil K tested medium with the Mehlich I soil test. Seasonal average fruit weight and percent marketable fruit decreased with increasing K rate. Seasonal fruit yields did not increase with K rates above 0.56 kg/ha/day. Leaf K concentrations increased with increasing K rates throughout the harvest season. The leaf K concentrations in the 0.28 K treatment were below 1% during the last month of harvest. K rates did not affect fruit firmness.

EFFECT OF HYDROPONIC SOLUTION NITROGEN CONCENTRATION ON 'CHANDLER STRAWBERRIES
David G. Himelrick and W. A. Dozier Jr, Department of Horticulture, Auburn University, AL 36849-5408

'Chandler' strawberry plants were grown in a nutrient flow hydroponic systems with six solution N treatments (35, 70, 140, 210, 280, 350 ppm). Total N was determined in leaf blade and petiole samples using Kjeldahl procedure and by LECO CHN analyzer. Nitrate-N was extracted with KCl and analyzed using a LACHAT ion analyzer. Correlations for total N in leaf blades with hydroponic N levels were $r^2 = 0.79$ for Kjeldahl, $r^2 = 0.25$ for LECO, and $r^2 = 0.60$ for LACHAT while petiole samples were $r^2 = 0.57$ for Kjeldahl, $r^2 = 0.55$ for LECO and $r^2 = 0.41$ for LACHAT. Vegetative characteristics of the plants were affected with the 210 ppm treatment producing both the most crowns and runners and 350 ppm the least.

057

IN VITRO SCREENING OF WESTERN UNITED STATES *VACCINIUM* SPECIES FOR pH TOLERANCE

Amy J. Moberg*, James J. Luby, Carl J. Rosen, and Peter D. Ascher, University of Minnesota, Dept. of Horticultural Science, 1970 Folwell Ave., St. Paul, MN 55108

Accessions of *Vaccinium* species (*deliciosum*, *ovalifolium*, *membranaceum*, *parvifolium*, *scoparium*) were evaluated for tolerance to higher pH in the root zone using an in vitro screening procedure. Seeds were germinated on media containing all essential nutrients with nitrogen in the nitrate form at pH 5 and pH 6 and evaluated for 21 weeks. Excess EDTA was used to buffer the micronutrients and pH was buffered by MES and succinic acid. Germination varied among species with *V. ovalifolium* being highest and *V. parvifolium* not germinating at all. Mortality was lower at pH 5. At pH 6, *V. ovalifolium* and *V. membranaceum* exhibited variation for growth while all other species suffered complete mortality.

058

DATE OF NITROGEN APPLICATION AFFECTS UPTAKE BY FIELD-GROWN BLUEBERRIES

Philip A. Throop* and Eric J. Hanson, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Absorption of "N-enriched fertilizer by young 'Bluecrop' bushes was compared following applications on six dates between April and Sept. Ammonium sulfate solutions containing 2.1 g N (10.2 atom % ^{15}N) were dripped directly into the root zone of single bushes. Soil covers and irrigation were used to maintain similar soil moisture conditions during treatment periods. Bushes were excavated after two weeks of exposure, and separated into roots, stems, and current-season growth (shoots, leaves, fruit). Tissues were dried, weighed, and analyzed for ^{15}N and ^{14}N by mass spectrometry. Bushes treated in May, June and July absorbed a greater percentage of applied N (6-8%) than bushes treated in Apr, Aug or Sept (1-3%). Results indicate that fertilization between late May and late July may result in the greatest efficiency of fertilizer use.

059

EFFECTS OF CALCIUM SPRAYS ON Highbush BLUEBERRY QUALITY

Eric J. Hanson, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

The effects of multiple calcium (Ca) sprays on berry quality of mature 'Bluecrop' plants was tested for two seasons. In 1992, treatments supplied a total of 0, 1.0, 1.9 or 3.8 kg Ca/ha, in five applications between 18 June and 16 July. Calcium was applied as CaCl_2 . Concentrations for the highest rate ranged from 0.08% Ca in the first spray to 0.2% in the last. In 1993, treatments included a control, 12.1 kg Ca/ha applied as CaCl_2 , 24.2 kg Ca as CaCl_2 , and 12.1 kg Ca as the commercial product Nutrical (CSI Chem., Bondurant, IA). Seven sprays were applied between 4 June and 16 July, using concentrations of 0.1% to 0.4% Ca. Treatments had no effect on the percentage of soft or rotten berries, berry firmness, or Ca concentrations in berries in either year. Leaf Ca levels were increased slightly by higher application rates.

27 ORAL SESSION 9 (Abstr. 060-066) Education

060

TEACHING INTRODUCTORY HORTICULTURE

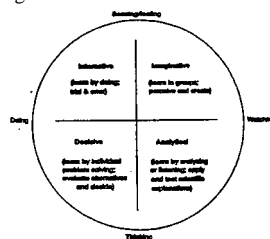
Judith D. Caldwell and David W. Reed*, Department of Horticulture, Clemson University, Clemson, SC 29631-0375 and Department of Horticultural Science, Texas A&M University, College Station, TX 77843. Introductory horticulture courses are taught in almost every 4 year and 2 year horticulture program across the country, however, purpose, content and approach can vary widely among schools. Survey results will show how different schools use their introductory course (recruiting, foundation, service), class composition, topics most commonly included, textbooks used, standard teaching techniques and new or innovative techniques that have been especially effective.

061

LEARNING PREFERENCES IN HORTICULTURE

Ray D. William, Oregon State University, ALS 4017, Corvallis, OR 97331-7304

Learning style preferences contribute to predictable actions by people. Basic researchers are fundamentally different than applied researchers in horticulture. Dilemmas associated with pesticides, worker protection, water, and labor issues often are related to differences in perception by relational versus linear thinkers. A participatory discussion will focus on these differences and how they can be combined to create dynamic and creative learning around complex issues facing horticulturists and consumers during the 1990's.



062

DECISION CASES TO ENHANCE LEARNING IN PRODUCTION HORTICULTURE COURSES

Emily Hoover*, Doug Foulk, and David Davis, Department of Horticultural Science, University of Minnesota, St. Paul, MN 55108.

Decision cases are designed to enhance students critical thinking by engaging them in authentic problem situations. Students are assigned the role as decision maker with a dilemma to solve. In the assignment, the decision maker has to weigh the issues, identify the options, and develop strategies for solutions either individually or as a group. The authors have been writing and using decision cases in upper level undergraduate production courses in fruits and vegetables to integrate information from classes in plant pathology, entomology, and production horticulture. Decision cases dealing with weed control strategies in small fruit production and vegetable production scheduling will be discussed to illustrate the strengths and weaknesses of the case approach.

063

IMPLEMENTING WRITING ACROSS THE CURRICULUM IN HORTICULTURE COURSES

Cynthia B. McKenney*, Department of Plant and Soil Science, Texas Tech University, Lubbock, TX 79409-2122.

Writing Across the Curriculum (WAC) programs are viewed as a plausible solution to poor student communication skills. These programs are further justified on the premise that writing fosters and reinforces learning in any discipline.

WAC programs integrate easily into horticulture. Traditional writing opportunities frequently utilized in horticulture include essays, papers, presentation critiques, lab reports, field trip summaries, business proposals, and cropping schedules. New opportunities might include microthemes and target audience writings.

WAC programs have their own share of pitfalls: increased grading time, reduced course content, ill-equipped faculty to teach

language arts, and unrecognized objectives. Ultimately, the success or failure of a WAC program hinges on the commitment of faculty in the discipline who should have the best understanding of the language and style needed to communicate effectively in their field.

063A

WRITING TO LEARN IN THE PLANT SCIENCES

Robert J. Joly, Department of Horticulture, Purdue University, West Lafayette, IN 47907-1165

Writing is a powerful tool for thinking and for clarifying complex subjects. It's a much more physical activity than reading. It compels students to organize their thoughts and present them clearly and logically. They must continually reassess whether what they've written is really what they want to say. The focus of this presentation is on the impediments to implementing this approach in our teaching. Our objective is to seek methods for reducing the work load of instructors while maintaining the quality of learning that can occur in a writing-intensive course. Results of workshops conducted during the 1993 North Central Regional Teaching Symposium entitled "Writing to Learn in Science" will be discussed. The workshops were active, participatory sessions designed to elicit as many responses as possible to the question "How can we utilize writing, intensively, in our courses?" Five obstacles or barriers to implementation of writing were identified. These include (1) instructor anxiety, (2) students requiring individualized instruction, (3) time-consuming evaluation of student writing, (4) in-class time needed for writing instruction, and (5) lack of student motivation. A focused-discussion format was utilized in these sessions, and groups of participants were given responsibility to devise creative actions or strategies that could be utilized to meet the challenges noted above. More than forty "actions" were identified which could help to make this approach feasible in both graduate and undergraduate courses. These are summarized within five broad strategic approaches.

064

OFFERING A CAPSTONE COURSE IN HORTICULTURE

Tim Rhodus*, Dept. of Horticulture, The Ohio State University, Columbus, OH 43210

Capstone courses generally target students who are nearing completion of their studies, are designed to build on skills acquired in earlier courses, and emphasize realistic situations and challenges that exist in the "real world". Specific learning goals and course objectives are found to vary across disciplines but most capstone courses provide an opportunity for students to demonstrate a range of professional competencies and communication skills. By incorporating computer simulations, case studies, or research projects, students are better able to develop critical thinking and problem solving skills, a learning goal frequently adopted following curriculum review. The goals and organization of "Quality, Ethics, and the Global Environment," the capstone course in Horticulture at The Ohio State University will be compared to other capstone courses.

065

USING THE SERVICE COURSE CONCEPT IN HORTICULTURE

Robert E. Lyons*, Dept. of Horticulture, Virginia Tech, Blacksburg, VA 24061-0327

An undergraduate "Service Course" generally presents principles of a particular discipline in an uncomplicated manner needing no prerequisites. The target audience is typically students majoring outside the service course department or undeclared majors. The primary motives behind service courses are recruitment from within the university, providing non-majors with a broad appreciation for a discipline, and providing graduate students with classroom teaching/management experience. The structure, dynamics, success, and adaptability of "Indoor Plants," a Virginia Tech Horticulture service course enrolling approximately 400 students per year, will be discussed. Comparisons with other service courses will be made.

066

A MODEL FOR REFORM OF UNDERGRADUATE HORTICULTURE EDUCATION: THE WASHINGTON TREE FRUIT PROGRAM

Mark K. Mullinix* and Paul Tvergyak, Wenatchee Valley College, 1300 Fifth Street, Wenatchee, WA 98801.

Horticulture departments have been experiencing a decline of students studying pomology and the tree fruit industry suffers from a shortage of horticulturists. Wenatchee Valley College responded to the tree fruit industry's request to develop an undergraduate pomology program. The program has an industry advisory committee, is industry oriented and emphasizes the art and the science of deciduous tree fruit production.

Industry and field-based instruction is a significant component of the curriculum. The fruit industry funded the development of two laboratory orchards totaling 53 acres. Industry satisfaction and student placement is high. Wenatchee Valley College's success motivated the industry to encourage the Washington State University Dept. of Horticulture and Wenatchee Valley College to join in an educational partnership. The Washington Tree Fruit Program was implemented in 1993. It is the state's first educational program cooperatively developed by two state institutions of higher education and boasts 55 degree-seeking students. The articulated curriculum has many innovations and represents a significant departure from traditional undergraduate pomology curricula.

28

ORAL SESSION 10 (Abstr. 067-073) Tree Fruit: Culture and Management

067

SHOOT ORIENTATION AFFECTS PEACH SHOOT AND FRUIT GROWTH
Paula M. Gross* and Stephen C. Myers, Department of Horticulture, University of Georgia, Athens, GA 30602.

One-year old fruiting shoots averaging 50 cm in length were tagged according to naturally-occurring orientations ranging from vertical to horizontal throughout the canopies of dormant 'Encore' peach (*Prunus persica* L. Batsch) trees. Following fruit set, tagged shoots were thinned to two or three fruit per shoot. Fruit diameter, terminal shoot extension, and shoot orientation were measured at intervals throughout the season. Fruit were harvested at uniform maturity based on ground color for assessment of fresh weight, diameter, percent red blush, and red color intensity. A linear relationship ($p < .001$) was found between final fruit size and initial orientation, with fruit diameters 6 percent larger on shoots initially oriented horizontally than those initially vertical. Fruit size differences were not detected until the last two to three weeks of growth. Fruit size response to orientation was found to be independent of light. Red color development was not influenced, probably due to fairly uniform light environments within the canopies. Terminal shoot length was linearly related to initial orientation, with shoots initially oriented horizontally having the least terminal shoot extension. Development of lateral shoot growth in relation to shoot orientation will be discussed.

068

EFFECT OF PRUNING SEVERITY ON APPLE TREE GROWTH, YIELD AND YIELD EFFICIENCY

Terence L. Robinson*, Dept. of Horticultural Sciences, New York State Agricultural Experiment Station, Cornell Univ., Geneva, NY 14456

'Empire'/M.26 apple trees which were planted in 1978 and trained to a Y-trellis were pruned differentially from 1989-1993. Trees were dormant pruned by removing from 1-4 scaffold limbs. The annual increase in trunk cross-sectional area (TCA), and the number and length of shoots removed during summer pruning increased linearly as the severity of pruning increased. The number of shoots removed during summer pruning from the most severe pruning treatment was more than double that of the least severe treatment. Cumulative fruit number and yield were reduced linearly with increasing severity of pruning while average fruit size was increased only slightly by severity of pruning. Light interception was reduced with increasing severity of pruning. Tree efficiency of converting light energy into fruit (g fruit/MJ PAR intercepted) was linearly reduced with increasing pruning severity. Most of the reduction in conversion efficiency appeared to be due to reduced partitioning of resources into fruit since partitioning index (g fruit/unit increase in TCA) was more highly correlated to pruning severity than to conversion efficiency. Conversion efficiency and partitioning index accounted for a greater portion of the yield variation than did light interception indicating that the influence of pruning on yield was more a function of changing internal physiology than reduced light interception.

069

EFFECTS OF APPLE BRANCH GIRDLING ON RETENTION AND QUALITY OF FRUIT AND VEGETATIVE GROWTH

Carl E. Mitchell* and John A. Barden, Department of Horticulture, Virginia Tech, Blacksburg, VA 24061

In 1992, branches on 'Triple Red Delicious'/M.7 were girdled. A factorial of treatments (control, 9mm girdle-uncovered, 9mm girdle-covered) and timings: 0, 15, 30, 60, & 90 days after full bloom (DAFB)

was used. With 'Golden Delicious' M.7, branch treatments were: control, score, and 6mm, 9mm, & 12 mm covered girdles, each applied at 0, 15, 30, & 60 DAFB. In 1993, treatments were: control, 9mm uncovered girdle, & pruning saw cut; each was applied 0, 7, 14, and 21 DAFB. Each girdle was a complete ring of bark; scoring was a knife cut through the bark.

The 2 cultivars responded similarly to girdling. Effects were greatest to treatments at 0-30 DAFB, and included increased fruit set or retention, temporary suppression of vegetative growth, and increased levels of soluble solids in the fruit. Treatments affected starch levels in the fruit and flesh firmness, but these effects were inconsistent.

070

EVALUATION OF APPLE TREE TRAINING TECHNIQUES FOR HIGHER-DENSITY ORCHARD SYSTEMS IN NORTH CAROLINA
Michael Parker* and Eric Young, North Carolina State University, Box 7609, Raleigh, NC 27695-7609

Controlling vegetative growth resulting from a long growing season in the southeast is difficult while trying to promote early fruiting. This study was initiated in 1990 to evaluate higher density leader training techniques, cultivar interactions, and the benefits of pre-plant fumigation on apple replant sites. Another objective was to evaluate these management parameters in four regions with very different climates and elevations. The training techniques evaluated were, weak leader renewal, bending of the leader during the growing season, and partial terminal leaf removal every 10 inches of leader growth (without injuring the apical meristem). The cultivars used were Jonagored, Spur Gala, and Red Fuji, all on Mark rootstock. First and second year branching was not significantly different between the various training techniques. Yields during the third year did not appear to differ between the leader training techniques. Pre-plant fumigation appeared to be beneficial in increasing tree growth in only two of the four sites.

071

EFFECT OF EXCESSIVE SOLAR RADIATION ON FRUIT QUALITY AND MINERAL NUTRITION OF 'GRANNY SMITH' AND 'DELICIOUS' APPLES
Eric A. Curry USDA/ARS Tree Fruit Research Laboratory, 1104 Western Avenue, Wenatchee, WA 98801

Warm daytime and cool nighttime temperatures during fruit maturation are conducive to anthocyanin synthesis and starch degradation in many apple cultivars. In parts of the world, high temperatures during fruit maturation result in sunburn of varying degrees of severity ranging from slight bleaching of the pigments in the epidermal layer to cracked and desiccated skin. This experiment assessed the effects of sunburn on fruit quality and mineral nutrition at harvest. In September 1990, about 2000 'Granny Smith' or 'Delicious' apples were examined for sunburn and sorted into the following categories: none, light, bleached, bronzed, buckskin, and cracked. Twenty fruit were collected for each category. Each fruit was subdivided into exposed and shaded halves. Each half of each fruit was evaluated for firmness, soluble solids, and acidity. Tissue samples were analyzed for sugars, total nitrogen, and mineral content. Data suggest that excessive heat due to solar radiation creates a gradient of sugars and minerals within the fruit resulting in increased disorders in certain areas of the fruit.

072

MITES AND CROP DENSITY INFLUENCE 'DELICIOUS' APPLES
Richard P. Marini* and Douglas G. Pfeiffer, Virginia Tech, Blacksburg, VA 24061-0327

'Campbell Redchief Delicious' trees were treated with a factorial combination of five European red mite (ERM) populations (range = 0 to 3000 cumulative mite-days per leaf (CMD)), and four crop densities (CD) (range = 2 to 12 fruit · cm⁻² trunk cross sectional-area) during two growing seasons. Yield was related positively to CD and negatively to CMD. In general, fruit weight, fruit surface red color, and fruit soluble solids concentration declined with increasing levels of CMD and CD. For most response variables, there was a significant CMD by CD interaction. Fruit were graded into six size categories and crop value was calculated. Crop value generally increased with increasing CD and declined with increasing CMD, mite feeding reduced crop value most at high CD. Crop value estimates were used to calculate economic injury levels. We propose economic injury levels of 1000, 500, and 300 CMD, respectively for spur 'Delicious' trees with light, moderate, and heavy crop loads.

073

A COMPARISON OF NATURAL AND SYNTHETIC MULCHES WITH CONVENTIONAL ORCHARD-FLOOR MANAGEMENT SYSTEMS
Ian Merwin*, Dave Rosenberger, and Cathy Engle, Dept. of Fruit and Vegetable Science, 118 Plant Science, Cornell Univ., Ithaca, NY, 14853

In several northeastern USDA Low-Input Sustainable Agriculture (LISA) projects, we compared natural (hay-straw, wood-chips, recycled newspaper pulp) and synthetic (polypropylene films and polyester fabrics) mulch materials with mowed sodgrass, tillage, and residual herbicides, as orchard groundcover management systems (GMS). Treatments were applied in 2m-wide strips under newly planted apple (*Malus domestica* cvs. Liberty, Empire, Freedom, and others) trees on MARK rootstock, planted at 3 by 5m spacing, in 1990. Edaphic, economic, tree nutritional and fruit yield impacts of these GMS were evaluated for four years in five Hudson Valley orchards. All the mulches cost more to establish and maintain (\$450 to 4500/ha) than mowed sod (\$150/ha), tillage (\$120/ha), or residual herbicide (\$50/ha) systems. There were few differences in soil water or nutrient availability, leaf nutrient content, tree growth or fruit yield in the mulch systems compared with herbicide or tillage GMS. Meadow voles (*Microtus* spp.) caused considerable damage to trees in the synthetic and straw mulches, despite the use of trunk guards. Wood-chips were the most enduring, least expensive, and most effective natural mulch. There were insufficient short-term benefits to offset the greater costs of synthetic mulch fabrics or films, in comparison with conventional herbicide snip systems for orchard floor management.

29 ORAL SESSION 11 (Abstr. 074-080) Cross-commodity: Modeling/Statistics

074

IMPLEMENTING EASTER LILY DEVELOPMENT MODELS IN A COMPUTER DECISION SUPPORT SYSTEM
Paul R. Fisher*, Royal D. Heins¹, Niels Ehler², J. Heinrich Lieth³, Poul Karlsen², and Michael Brogaard¹, ¹Department of Horticulture, Michigan State University, East Lansing, MI 48824, ²The Royal Veterinary and Agricultural University, Copenhagen, Denmark, ³Department of Environmental Horticulture, University of California, Davis, CA

Commercial production of Easter lily (*Lilium longiflorum* Thunb.) requires precise temperature control to ensure that the crop flowers in time for Easter sales. The objective of this project was to develop and validate a greenhouse decision-support system (DSS) for producing Easter lily to predetermined height and flower date specifications. Existing developmental models were integrated with a knowledge-based system in a DSS to provide temperature recommendations optimized for Easter lily scheduling and height control. Climate data are automatically recorded in real time by linking the DSS to a greenhouse climate control computer. Setpoint recommendations from the DSS can be manually set or automatically implemented in real time. Potential benefits of the project include improved crop quality and the transfer, validation, and integration of research-based models. The DSS was implemented at several research and commercial locations during the 1994 Easter lily season. DSS recommendations were compared with the strategies of experienced growers. The system design, implementation, production results, quality of recommendations, and potential are discussed.

075

MODELING ORIENTAL LILY 'STARGAZER' DEVELOPMENT RATE TO CREATE A DECISION-SUPPORT TOOL.
Royal D. Heins* and James Faust, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

A decision-support tool for the Oriental lily 'Stargazer' was developed from developmental data. Flower buds were measured twice a week on plants growing in greenhouses maintained at 15, 18, 21, 24, or 27°C. For each temperature, days to flower (DTF) was modeled as a linear function of the natural logarithm of bud length, DTF = b₀ + b₁ * ln (bud length). Both parameters (b₀ and b₁) of the linear function were a quadratic function of average daily temperature (ADT). Both parameters of the linear function were then modeled so DTF = (397.6 - 24.5 * ADT + 0.469 * ADT²) + (-83.5 + 5.13 * ADT - 0.098 * ADT²) * ln (budlength in mm). A decision-support tool, shown below, was developed from the model to assist with crop timing.

39	27	21	16	12	9	7	5	3	0	27 C (80 F)
40	28	21	16	13	10	7	5	3	0	24 C (75 F)
45	32	24	19	15	11	8	6	3	0	21 C (70 F)
55	39	30	23	18	14	10	7	5	2	18 C (65 F)
65	47	36	28	22	17	13	9	6	3	16 C (60 F)
10	20	30	40	50	60	70	80	90	100	
Bud Meter for Stargazer lines grown under Long Days (night-interruption lighting)										MICHIGAN STATE UNIVERSITY

076
COMPONENTS OF A FLOWERING MODEL IN *HELICONIA ANGUSTA*
Funoh Kwon and Richard A. Criley*, Horticulture
Dept., University of Hawaii, Honolulu, HI 96822

Bright red bracts with white flowers are produced by *H. angusta* from Sept through Dec in Hawaii. The inflorescences are valued as cut-flowers and the species is potentially adaptable as a seasonal potted plant. Sakai et al (1990) reported the LD responsiveness of this species, but additional detail was necessary to permit scheduling. EK's PhD thesis developed a model for flowering in which the minimum daylength requirement to initiate was 13 hr for 7 wk with another 15-16 wk required for development irrespective of the daylength (12-18 hr) or temperature (14-22C). As with other photoperiodically sensitive heliconias, 3 unfurled leaves were required to respond to LD. A growing degree model was developed to determine the time necessary to reach the 3-leaf stage. A 30-year temperature record was used to estimate the latest shoot emergence date that would permit initiation, development, and flowering under Honolulu conditions. The model was validated by comparison with commercial production records. Sakai et al. 1990. *Bul Heliconia Soc Intl* 4(4):10-11

077

Modeling Nitrogen Status of Chrysanthemum in a Growing Container
Mark V. Yelanich* and John A. Biernbaum. Department of Horticulture,
Michigan State University, East Lansing, MI 48824-1325

A model was constructed to dynamically simulate how the nitrogen concentration changes in the root zone of a pot grown chrysanthemum. The root zone concentration of nitrogen is predicted at any time during the crop by predicting the root zone contents of nitrogen and water. The root zone content of nitrogen is predicted by integrating the rates of nitrogen applied, taken up by the plant and entering the top layer of the pot. The root zone water content is predicted by integrating the rates of water applied, evaporated from the media surface and transpired by the plant. Simple models were constructed to predict the various rate processes. For example the rate of nitrogen uptake was modeled as a function of the dry mass accumulation and was broken down into demands of nitrogen by the plant for maintenance of the current dry mass and for support of new growth. Dry mass accumulation was modeled as a function of the amount of PPF which could be intercepted by the plant. The model was validated using plants grown in growth chambers and greenhouses at various PPF levels and fertilizer concentrations. The model will be used to test the risks involved in using various fertilizer strategies and to develop more efficient fertilization strategies.

078

REDUCING AGRICULTURAL POLLUTION WITH RIPARIAN
BUFFER SYSTEMS

Lee S. Altier*, R. Richard Lowrance, and R.G. Williams, Southeast
Watershed Research Lab, USDA/ARS, P.O. Box 946, Tifton, GA 31793

Even with careful management, within-field practices are often insufficient to prevent considerable nonpoint source pollution to adjacent streams. Water resources suffer from sediment, N, and P transported in surface runoff and N in subsurface movement when fields are cultivated up to stream banks. The maintenance of forested buffer systems between farmland and streams has been proposed as a remedy for mitigating pollution. Chemical movement through such a buffer system has been monitored for several years at the University of Georgia Coastal Plain Experiment Station. With the aid of that data, the Riparian Ecosystem Management Model is being developed to simulate biological, chemical, and hydrologic processes in order to evaluate the effectiveness of buffer system management for reducing the influx of pollutants to streams. The model allows an examination of the long-term potential of a buffer system under changing environmental conditions.

079

ENVIRONMENTAL ANALYSIS: AN ALTERNATIVE AND
ENHANCEMENT TO ANOVA.

Burton J. Hoyle, 520 Union St., Arcata, Ca 95521

Environmental analysis (EA) is described as a simplified system for determining significant differences between individual and groups of treatments within a test plot. It is based on recognizing and using the fact that each data point comes from a different environment in the soil. So called effects of blocks, rows and col-

umns are ignored and replicates are ranked. Ranges of treatments are compared at corresponding levels of most to least favorable environment. The magnitude of a replicate is used only to indicate equal or better of one to another treatment. Significance levels are calculated or looked up in tables. EA is hundreds of times faster than ANOVA or regression analysis; results can often be obtained quickly by hand. Examples of EA are compared to ANOVA plus LSD and regression analysis. In all cases, results obtained by EA were nearly the same for the examples discussed. The predictive value of EA appears to be superior to the other methods. Techniques are shown for atypical ranking and other characteristics.

080

PREDICTING APPLE ROOTSTOCK PERFORMANCE FROM
ENVIRONMENTAL VARIABLES

W.C. Olien*, Department of Horticulture, Clemson University, Clemson, SC 29634, D.C. Ferree and B.L. Bishop, Department of Horticulture and Statistics Laboratory, Ohio State University, OARDC, Wooster, OH 44691

Rootstock recommendation is complicated by performance-site interactions. The NC140 Regional Project recently completed a 10-year evaluation of 9 rootstocks in locations across North America. Based on this data, we developed stability analysis models and demonstrated significant rootstock-site interactions for cumulative yield (CY) and trunk cross-sectional-area (CSA). The models require a site index (SI) estimated from mean performance over rootstocks within site. Prediction of rootstock performance in untested sites would be possible with an independent estimate of SI. We tested prediction of SI from mean maximum temperature (T) and total moisture received (M) and divided T and M into 5 phenological periods: Dec-Jan (Dormant), Feb-Apr (Prebloom), May-Jun (fruit Set), July-Sept (fruit Growth), and Oct-Nov (Postharvest). ³CSA was not predicted by any T or M variable. ³CY was predicted by ¹Set, ¹Grow, and ³Set, but ¹Set and ³Set were codependent. ³CY was best predicted from a linear relationship with ¹Set.

49 ORAL SESSION 12 (Abstr. 081-087)

Tree Fruits and Nuts: Water and Temperature Stress

081

A PLANT-BASED MEASURE FOR DETERMINING TREE WATER NEEDS
K. Shackel* S. Southwick, and B. Lampinen, Pomology Department,
University of California, Davis, CA 95616-8683

To be useful for indicating plant water needs, any measure of plant stress should be closely related to some of the known short and medium term plant stress responses, such as stomatal closure and reduced rates of expansive growth. Methods for the measurement of plant water potential (Ψ) are available, but conflicting results have led to disagreement as to whether any of these give an appropriate biological index of plant water stress. Some pressure chamber results may be attributed to an artifact of water loss following excision. Leaf and stem Ψ however, in addition to being numerically different, may not be equivalent indices of plant stress, and midday stem Ψ has proven to be a useful index of stress in a number of fruit trees. Day to day fluctuations in midday stem Ψ under well irrigated conditions is well correlated to midday Vapor Pressure Deficit, and hence can be used to predict a non-stressed baseline. A 50% decline in water use at both the leaf and canopy level were associated with relatively small reductions (0.5 to 0.6 MPa) in midday stem Ψ from this baseline in prune. In cherry, midday stem Ψ was correlated to both leaf stomatal conductance and rates of shoot growth, with shoot growth essentially stopping once midday stem Ψ dropped to between -1.5 to -1.7 MPa. In pear, increased fruit size, decreased fruit soluble solids and increased green color were all associated with increases in midday stem Ψ .

082

OFFSETTING EFFECTS OF REDUCED ROOT HYDRAULIC
CONDUCTIVITY AND OSMOTIC ADJUSTMENT IN DROUGHT-STRESSED
PEACH, OLIVE, CITRUS, AND PISTACHIO

M. Rieger, Department of Horticulture, University of Georgia, Athens, GA 30602

Root hydraulic conductivity (L_p) and osmotic potential (π) were measured in young, drought-stressed and non-stressed peach (*Prunus persica*), Olive (*Olea europaea*), Citrumelo (*Citrus paradisi* x *Poncirus trifoliata*) and Pistachio (*Pistachia integerrima*) plants. Drought stress reduced L_p 2.5 to 4.2-fold, depending on

species, but π was reduced only in expanded citrumele leaves and unexpanded olive leaves by 0.34 and 1.4 MPa, respectively. A simulation model of plant water uptake and leaf water relations was constructed to quantify the offsetting effects of reduced Lp and osmotic adjustment (OA) on turgor maintenance. For olive data, a 2.5-fold reduction of Lp caused a linear decrease in turgor pressure difference between stressed and non-stressed plants, such that the effect of OA was totally offset at a leaf water potential (stressed) of ≈ -3.0 MPa. For citrumele, because the degree of OA was lower, the water potential at which the effects of OA and reduced Lp were offsetting with respect to turgor maintenance was ≈ -0.6 MPa. The analysis suggests that some level of stomatal closure would be necessary to extend the water potential range over which stressed plants maintain higher turgor than non-stressed plants for citrumele. Conversely, no degree of stomatal closure would be required of stressed olive plants to maintain higher turgor than non-stressed counterparts over a physiologically meaningful range of leaf water potential.

083

FRUIT HYDRAULIC BUDGETS IN FRENCH PRUNE (*PRUNUS DOMESTICA* L. CV. FRENCH) AND THEIR EFFECTS ON FRUIT GROWTH AND CRACKING

Rémy E. Milad* and Kenneth A. Shackel, Department of Pomology, University of California, Davis, CA 95616

End cracking of French prune fruits occurs when previously water stressed trees are irrigated during early July. Fruit phloem, xylem and transpiration flows (P, X and T, respectively) were measured diurnally during 72 h periods in mid June, early July and mid July (before, during and after the crack-susceptible period). Midway through each 72 h period, the previously stressed trees were irrigated. In mid June, X was larger than P, whereas P was larger than X during early July. In mid July, P and X were similar. In early July, the period preceding irrigation was characterized by an *outflow* of phloem sap during the day and phloem inflow during the night. After irrigation, larger phloem inflows were observed and no phloem outflow occurred. Fruit transpiration rates were highly correlated with VPD. They exhibited a gradual decrease during the season, reaching minimum values during early July, before increasing again. The sum of P and X was virtually identical for the three periods i.e. stronger P's compensated for weaker X's and vice versa. Our results suggest that properties intrinsic to the fruit play the primary role in modulating water and photosynthate movements between the tree and the fruit. The possible role of these properties on fruit growth and cracking will be examined.

084

WATER STRESS, PHOTOPERIOD, AND DIURNAL DISTRIBUTION OF SORBITOL CARBOHYDRATES IN APPLE

Zhongchun Wang* and Bruno Quebdeaux, Department of Horticulture, University of Maryland, College Park, MD 20742-5611

One-year-old 'Gala' apple trees which experienced either water stress (WS) or no stress (CK) were exposed to a 60-min pulse of $^{14}\text{CO}_2$. The distributions of newly-fixed ^{14}C -photosynthates and total individual carbohydrates (both labelled and non-labelled) were monitored every 2 or 4 h for a 24-h period. During the 24-h period, half the WS and CK plants received 24-h continuous light and the other half received a 12-h photoperiod (8:00 AM to 8:00 PM). WS stimulated the ^{14}C partitioning into sucrose (suc) during the first 2-4 h period while the partitioning into glucose (glu) and fructose (fru) was inhibited in mature leaves. WS significantly inhibited the partitioning of ^{14}C into starch. At the end of the 24-h period, a greater partitioning of ^{14}C into sorbitol (sor) was observed under WS in leaves, stems and roots. WS lowered starch levels in all plant parts and the dark cycle further stimulated starch breakdown. Starch breakdown during the dark cycle resulted in the accumulation of glu and suc but not sor whereas in light sor accumulated with higher sorbitol/starch ratios. Light and energy requirements for sor synthesis and metabolism will be discussed.

086

SEVERITY OF LEAF SCORCH AND BLACK APHID DAMAGE TO PECAN AS RELATED TO WATER AVAILABILITY

Bruce W. Wood*, Charles C. Reilly and W. Louis Tedders. U.S. Dept. of Agriculture, Agricultural Research Service, Byron, GA 31008.

Two years of observations on water availability, black aphids and leaf scorch provides evidence of substantial interaction among these factors. Foliage of irrigated trees of 'Desirable', 'Cheyenne', and 'Wichita' cvs. exhibited much less leaf scorch, black aphid damage, free nitrogenous substances, and sugars than did nonirrigated trees.

Water stress appears to predispose foliage in such a way so as to greatly increase the ability of black aphids, and certain fungal pathogens to grow and/or reproduce on/in the affected foliage.

This appears to be associated with the organisms ability to induce

biochemical changes that increase levels of free nitrogenous substances and sugars. The level and degree of chlorosis and area of foliar damage by black pecan aphids was much greater on nonirrigated trees.

Two years of observations on the relative resistance of about 50 cultivars resulted in genotype related differences in susceptibility to leaf scorch.

087

RELATIONSHIP BETWEEN SUMMER TEMPERATURE AND DEEP SUTURE FORMATION IN 'BING' SWEET CHERRY

S. M. Southwick*, K. Shackel and J. T. Yeager, Pomology Department, University of California, Davis, CA 95616-8683

'Bing' sweet cherry is the most widely planted cultivar grown in the Western US because of widespread market acceptance. High prices are associated with early maturing 'Bings' so growers are inclined to plant in early maturing growing regions. High numbers of less marketable, abnormally shaped (deep sutures, spurs, doubles) fruit tend to be produced in these regions. It is thought that abnormal fruit development is associated with high summer temperatures. Dataloggers equipped with thermocouples were located in 7 California cherry growing regions. Thermocouples were positioned throughout tree canopies, monitoring flower bud temperatures for 2 seasons from May to October. A Richard's function was used to describe the relation of average daily temperature (July, August, September to the percentage of fruit with deep suture. Correlation coefficients (R^2) of 0.85 and higher were found, with increases in average daily temperatures above 22°C associated with the formation of abnormal fruit shapes. Heat lamps were used to increase spur temperatures 5-7°C above ambient during the July through September period. High percentages of abnormal flowers were produced in the season after 2 July, but not after 21 August heating. Strategies to lower high summer canopy temperatures helped to reduce abnormal fruit shapes.

50 ORAL SESSION 13 (Abstr. 088-094)

Grape: Culture/Management/Stress

088

INFLUENCE OF ROOTSTOCK AND VINE SPACING ON THE CONCENTRATION OF MINERALS IN PETIOLES AND FRUITS OF CABERNET SAUVIGNON GRAPEVINES GROWN IN NAPA VALLEY.

W. Mark Kliever* and Jason Benz, Department of Viticulture and Enology, University of California, Davis, CA 95616

The effects of 7 rootstocks (AxB#1, 110R, 5C, 3309, 420A, 1616 and 039-16) grafted to Cabernet Sauvignon (clone #8) in combination with 3 between row spacings (2, 3, and 4 m) and 2 in-row spacings (1 and 2 m) on the level of minerals in petioles sampled at full bloom and at veraison on the mineral composition of fruits at harvest were evaluated over a 3 year period (1991 to 1993) in a replicated field plot established at Oakville in 1987. 039-16 petioles had the highest level of K, Ca and NO_3 , whereas 420A had the lowest concentration of these minerals, the other 5 stocks being intermediate. Petiole Mg level was highest in 420A and lowest in 039-16. 039-16 fruits at harvest had the highest level of K, malate, and pH, whereas 420A fruits were lowest in these substances. Between row spacing showed no significant effects on the concentration of minerals in leaves and fruits. However, leaves from vines spaced 1 m apart within rows had lower levels of Ca and Mg than 2 m vine spacing. One m vine spaced fruits were lower in °Brix but higher in titratable acidity and malate than 2 m vine spaced fruits. Regression analysis showed that the number of roots per unit volume of soil was positively related to the concentration of K in leaves and fruits, regardless of the rootstock used.

089

EFFECT OF ROOTSTOCK ON GROWTH, PRODUCTIVITY, AND FRUIT COMPOSITION OF ZINFANDEL GRAPEVINES. R.K. Striegler* and D.R. Wineman, Viticulture and Enology Research Center, CSU, Fresno, Fresno, CA 93740-0089.

Selected rootstocks were evaluated for four seasons in a Zinfandel vineyard located in the northern San Joaquin Valley of California. The vineyard was drip-irrigated and vineyard spacing was 2.1m x 3.3m (vine x row). A two-wire vertical trellis system was used and row orientation was east to west. Vines were trained to a bilateral cordon and spur-pruned. Rootstocks included in the study were: AxB #1, Freedom, Harmony, Kober 5BB, and Teleki 5C. Vines grafted on AxB #1 rootstock were considered to be the control treatment.

A randomized complete block experimental design was used. There were six blocks and plots consisted of five vines. Data collected included yield, components of yield, fruit composition, bloom petiole nutrient content, shoot number, and pruning weight.

After the initial season, yields were consistently

highest for vines grafted on Freedom rootstock, with yields only slightly lower on AxR #1 rootstock. Significantly lower yields were recorded for vines grafted on Kober 5BB and Teleki 5C. Rootstock did not have a consistent effect on fruit composition. Shoots/vine and shoots/meter of canopy were not significantly affected by rootstock. Dormant pruning weight was highest for Freedom and lowest for Kober 5BB.

These results suggest that rootstock selection can influence vineyard productivity in the northern San Joaquin Valley. Continued research is needed to determine long term effects of the rootstocks used in this study.

090

THE EFFECTS OF WATER-STRESS, ROOTSTOCK AND CROP LOAD ON VINE AND ROOT GROWTH IN SEYVAL GRAPEVINES.
Mike McLean*, Stan Howell, and Alvin Smucker, Dept. of Horticulture (MM and SH) and Dept. of Crops and Soil Sciences (AS), Michigan State University, East Lansing, MI 48824.

This experiment was conducted to evaluate interrelationships between differing crop loads and water stress on carbohydrate partitioning for above and below-ground tissues of Seyval grapevines grafted on three different rootstocks. Fine root development and depth were determined by quantifying root images from video recordings taken to depths of 80 cm at approximately 2 week intervals throughout the growing season. Two-year own-rooted Seyval grapevines, and Seyval grafted to 5BB and to Seyval were grown under a rain exclusion shelter and provided with 10 or 2.5 liters of water/plant/week. Treatments were cropping level, either 0 or 6 clusters per vine. Shoot length, number of mature nodes, leaf area and dry leaf weight of vines under high cropping level were reduced compared to vines growing under the low cropping level; so was root number and depth of penetration. Conditions of low soil-moisture resulted in carbohydrate partitioning in favor of the clusters at the expense of the roots, and carbohydrate partitioning in favor of the roots at the expense of the above-ground vegetation.

091

PHYSIOLOGICAL AND BIOCHEMICAL RESPONSES OF GRAPEVINES TO METHANOL

Imed Dami*, Cecil Stushnoff and Richard Hamman, Department of Horticulture, Colorado State University, Fort Collins, CO 80523 ; OMRC, Grand Junction, CO 81503

The response of grapevines to methanol was investigated at the Orchard Mesa Research Center in Grand Junction, CO. Optimum sub-lethal methanol dose levels, based on visual assessments, were 90% for leaves and 100% for trunks for 10 cultivars. Total soluble sugars (TSS) of the berries, monitored every week until harvest, showed significant differences with Muscat Blanc during veraison. Berries from the methanol-treated vines had higher TSS (16.4 °Brix) than controls (15 °Brix). However, no significant differences were observed later in the season when approaching fruit maturity. At harvest, data on yields as estimated by cluster weight, berry weight and berry size showed no differences between the two treatments. Methanol did not enhance cold hardiness of bud tissues, measured by differential thermal analysis. It was concluded that, although methanol has been reported to improve several physiological features of C₃ crops, our study suggested that it has little or no practical effect on grapes. More data on the determination of sugars in berries by HPLC will be discussed.

092

MEASUREMENT OF GRAPEVINE WATER USE WITH A WEIGHING LYSIMETER

Larry E. Williams, Department of Viticulture and Enology, University of California, Davis, CA 95616

A weighing lysimeter (with a soil container 2 m wide, 4 m long and 2 m deep) was installed at the University of California's Kearney Ag Center in 1987. Diurnal, daily and seasonal vine water use has been measured yearly since then. Vine water use was 350, 400 and 580 mm the first, second and third years after planting, respectively. Vine water use (from budbreak to October 31) the subsequent four years averaged 815 mm per year. Reference crop ET (ET_c) averaged 1172 mm (from budbreak to October 31) over the course of the study. Diurnal vine water use was highly correlated with the diurnal course of solar radiation. Maximum ET averaged 50 L vine⁻¹ day⁻¹ during the middle part of the growing season. Experimental vines surrounding the lysimeter were irrigated at various fractions (from 0 to 140% in increments of 20%) of vine water was measured with the weighing lysimeter. Maximum yields were obtained with the 80% irrigation treatment. This study demonstrated the deleterious effects of both over and under irrigation on yield of grapevines.

093

POSITION OF SUNLIGHT-EXPOSED CLUSTERS INFLUENCES DIURNAL PATTERNS OF FRUIT TEMPERATURE

Thomas J. Zabada* and Thomas W. Dittmer,

Michigan State University, Southwest Michigan Research and Extension Center, Benton Harbor, MI 49022

Sunlight-exposed clusters of *Vitis vinifera* L. cv. Chardonnay at twelve positions on a N-S oriented, single curtain trellis were monitored for temperature to determine their patterns of heat summation and diurnal temperature.

Diurnal patterns of temperature differed greatly among these clusters. These differences reflected the solar insolation on individual clusters. Point-in-time measurements among clusters during mid-day varied as much as 12°C. 24-hour heat summation for these clusters revealed little difference among them. Heat summations for periods of daylight or solar insolation indicate more heat accumulation for clusters on the top of the trellis, at ground level and on the west side of the trellis than on the east side of the trellis. These differences might be usefully exploited when training vines to maximize aspects of fruit maturation in relatively cool climates.

094

CROPLoad EFFECT ON BUD COLD HARDINESS OF *Vitis labruscana* L. cv. CONCORD

Robert L. Wample*, Lynn Mills and Anna Wichers, Washington State University, IAREC, Prosser, WA 99350-9687

An increase in mechanical pruning of Concord grapevines in Washington has led to a marked increase in yield. In 1993 the average yield for the 20,000 plus acres was slightly greater than 12 ton/acre. As part of a long term study, initiated in 1987, to evaluate the effects of mechanical pruning on Concord yield and fruit quality, we have also followed bud cold hardiness and winter injury over several years. Cold hardiness was monitored using low temperature exotherm analysis of excised buds. Winter injury was evaluated by visual examination of bud and cane tissues collected from vines with different croploads. In 1990 the average yield for mechanically pruned vines was 13T/ac and for balance pruned vines about 8T/ac. Winter injury during December 1990 showed significantly less injury to mechanically pruned vines whether primary, secondary or tertiary buds were examined. During the winter of 1991-92 and 1993-94 bud cold hardiness of individual vines showed no relationship to cropload per vine.

51 ORAL SESSION 14 (Abstr. 095-101)

Floriculture: Light/Temperature

095

ROSETTING OF LISIANTHUS INFLUENCED BY CULTIVAR, SEEDLING AGE, PHOTOPERIOD, AND TEMPERATURE

Brent K. Harbaugh, Univ. of Florida, Gulf Coast Research and Education Center, 5007 60th Street East, Bradenton, FL 34203

Rosetting response was determined for four lisianthus [*Eustoma grandiflorum* (Raf.) Shinn.] cultivars exposed to photoperiod and temperature treatments during stage 1 (14 to 43 days after sowing) and stage 2 (43 to 79 days after sowing) seedling development. Stage 1 seedlings were exposed to short days (12 h photoperiod) or long days (18 h photoperiod) in combination with high (26°C) or low temperatures (12°C). After stage 1 treatments, stage 2 seedlings were divided and exposed to the same treatment combinations resulting in 16 treatments. Seedlings were then grown at 22°C for 120 days to determine rosetting response. Cultivars responded differently to temperature and photoperiod. Short day-high temperature exposure during either stage 1 or stage 2 resulted in the greatest number of rosetted plants (50 to 100%) for 'Yodel White', 'HeidiPink', and 'BlueLisa'. 'GCREC-Blue' did not rosette with short day-high temperature. Low temperature during stage 1 did not prevent rosetting when stage 2 seedlings were subsequently exposed to high temperature, but low temperature during stage 2 decreased rosetting of seedlings exposed to high temperature in stage 1. Less rosetting occurred with long day-high temperature than with short day-low temperature, especially for 'Blue Lisa'.

QUANTIFYING THE EFFECT OF SUPPLEMENTAL LIGHTING ON PLANT TEMPERATURES IN GREENHOUSES

James E. Faust* and Royal D. Heins, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

The effects of supplemental lighting on vinca (*Catharanthus roseus* L.) plant temperature were quantified in greenhouses maintained at air temperatures of 15, 25, and 35°C. High-pressure sodium (HPS) lamps delivering 100 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPF provided 73 $\text{W}\cdot\text{m}^{-2}$ of total radiation (400 to 50,000 nm) to lighted plants. Plant shoot-tip temperature was measured by using 40-gauge thermocouples. Relative to air temperature, plant shoot-tip temperature depended on the irradiance and vapor-pressure deficit (VPD). Irrespective of VPD, the additional irradiance absorbed by plants under the HPS lamps increased plant temperature 1 to 2°C. Under relatively low VPD conditions (1 kPa), plant temperature was greater than air temperature, while under high VPD conditions (4 to 5 kPa), temperature of both lighted and unlighted plants remained below air temperature throughout the day. Temperature of lighted plants however, remained 1 to 2°C above that of unlighted plants. Analysis of a degree-day model of vinca development showed hastened development associated with supplemental lighting could be explained by increased plant temperature rather than any specific photosynthetic effect.

097

EFFECT OF EXTENDED LIGHTING ON POINSETTIA 'ECKESPOINT FREEDOM'

G. J. Wilfret*, Gulf Coast Research & Education Center, IFAS, Univ. of FL, 5007 60th St. E., Bradenton, FL 34203

Poinsettia 'Eckespoint Freedom' (*Euphorbia pulcherrima*), grown as single pinched plants in containers in a shade house (30% light exclusion) during 1992 and 1993, were provided interrupted night lighting from 2200 to 0200 hr. to determine the effect of extended lighting on vegetative and reproductive development. Plants were moved to short days at 2 day intervals from 14 Sept to 26 Oct 92 and from 26 Sept to 26 Oct 93 and were compared to plants grown with ambient daylengths. Dates of first bract in full color for ambient-day plants were 31 Oct 92 and 04 Nov 93. Marketable dates (5 bracts in color) for ambient-day plants were 21 Nov 92 and 18 Nov 93. Bract development was delayed in direct proportion to lighting beyond 02 Oct 92 and 04 Oct 93. Number of vegetative nodes increased from 7.4 to 12.8 and from 6.3 to 12.0 when ambient-day plants were compared to plants lit to 26 Oct of 1992 and 1993, respectively. Lateral stem caliper, measured 2 cm above the axil, was significantly greater on plants lit beyond 10 Oct. Plant stature was more upright when lit beyond 16 Oct, which was 30 days from pinching.

098

ACCELERATING GROWTH OF PLUG-GROWN PANSIES WITH CARBON DIOXIDE AND LIGHT

Mark P. Kaczperski*, Allan M. Armitage and Pamela M. Lewis, Department of Horticulture, University of Georgia, Athens, GA 30602

Seed of *Viola* \times *wittrockiana* 'Majestic Giant Yellow' were germinated in #406 plug trays at ambient CO_2 , 25°C and a light intensity of 100 $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ with an 18 hr photoperiod. At emergence and at successive one week intervals, seedlings were exposed to CO_2 levels of 500, 1000 or 1500 $\mu\text{l}\cdot\text{l}^{-1}$ and irradiances of 100, 225, 350 $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ for 7 to 35 days, after which seedlings were transplanted into 10 cm pots and grown to flower in the greenhouse. CO_2 at 1000 $\mu\text{l}\cdot\text{l}^{-1}$ was as effective as 1500 $\mu\text{l}\cdot\text{l}^{-1}$ in accelerating growth in the plug stage. 500 $\mu\text{l}\cdot\text{l}^{-1}$ at all irradiances did not accelerate growth significantly. Plants grown at 1000 $\mu\text{l}\cdot\text{l}^{-1}$ and 225 $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ intensity reached the 5 leaf stage up to 14 days earlier than the control, as well as decreasing time to flower during the growing on phase.

099

LIGHT AND TEMPERATURE AFFECT SPIKING AND FLOWERING OF THE PHALAENOPSIS ORCHID

Yin-Tune Wane*, Texas A&M University Agricultural Research and Extension Center, 2415 East Highway 83, Weslaco, TX 78596

To determine the impact of light on spiking during forcing, mature pot-grown *Phalaenopsis* Joseph Hampton 'Diane' plants were exposed to 0, 8, 60, or 160 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ of PPF while being subjected to 20°C day/15°C night (12 hr each) air temperatures for six weeks. Flower spikes emerged in an average of 27 and 33 days for plants exposed to 160 and 60 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPF, respectively. Those exposed to 8 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ of PPF or kept in darkness did not spike after six weeks. In a second experiment, plants were kept in complete darkness for 2, 4, or 6 weeks at 20°C day/15°C night before exposed to 160 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ of PPF

for six weeks. The average days to spiking for those kept in darkness for 2, 4, and 6 weeks were 30, 31, and 35, respectively, after lighting began. Therefore, light exceeding a certain level is required during the induction of spiking. Regression analysis of the results from a third experiment shows that, at a common day temperature of 25°C, anthesis was delayed by one day for each 1°C decrease in night temperature between 25°C and 15°C. Night temperature had no effect on flower count or size.

100

ROLE OF LIGHT INTENSITY IN THE DEVELOPMENT OF OSTRICH FERN

Matthew Donelan* and Kenneth Corey Department of Plant & Soil Sciences, University of Massachusetts, Amherst, MA 01003

Crowns of ostrich fern (*Matteuccia struthiopteris* L. Todaro) were field-planted in June 1993 on a Hadley silt loam in South Deerfield, Mass. Shade cloth was used to alter light intensity to determine if light intensity effects growth and development of fronds and crowns. Light levels were 22% (low), 45% (intermediate), 72% (high), and 100% (full) of ambient conditions. Survival of crowns decreased with increasing light intensity with only 22% survival under full light. Low, intermediate, and high light levels resulted in 89%, 75%, and 56%, respectively, of crowns producing shoots. Light intensity did not effect the number or length of fronds produced. Frond length reached a maximum after 2 months growth. Development of secondary crowns was enhanced at intermediate and high light intensities. Final crown weight was significantly correlated with initial crown weight regardless of light intensity. Crowns will be vernalized and forced hydroponically to determine effects of light intensity and crown size on growth of croziers.

101

EVALUATION OF PLANT WATER USE AND CROP TEMPERATURE OF NEW GUINEA IMPATIENS (IMPATIENS X HB.) UNDER INFRARED HEATING

Abdulelah Al-Faraj, George Meyer and Jay B. Fitzgerald*, Departments of Biological Systems Engineering and Horticulture, 377 Plant Science, University of Nebraska, Lincoln, NE 68583-0724

A plant-based temperature control system for infrared heating to maintain the plant canopy at a desired temperature was evaluated under growth chamber conditions with possible projections to greenhouse environment. Benefits for using this system includes energy saving and plant protection. Infrared radiant heaters raised canopy temperatures to the optimum range which increased water use of New Guinea Impatiens over the same kind of plants grown with no radiant heat. Plant water use was 118% higher at an 18°C air temperature vs. 8°C air temperature and 33% higher at 24°C air temperature vs. 18°C air temperature. The degree of increase in plant water use was proportional to decrease (leaf air) temperature. The Penman-Monteith equation gave satisfactory results when the differential between leaf and air temperature was very low. At high (leaf-air) temperature deviation, the latent heat equation used to estimate stomatal resistance gave higher values for heated plants.

52 ORAL SESSION 15 (Abstr. 102-107) Woody Ornamentals/Landscape/Turf: Culture and Management

102

EFFECT OF BACKFILL AND PLANTING BED AMENDMENTS ON GROWTH AND DROUGHT TOLERANCE OF *ACER RUBRUM*
Timothy J. Smalley* and Carleton B. Wood,
Department of Horticulture, University of Georgia, Athens, GA 30602.

Commonly used planting techniques and soil amendments were compared to determine their effect on root growth, shoot growth, and drought tolerance of 2.5 cm caliper *Acer rubrum*. Study I: Trees were planted on 6 April 1992 into holes backfilled with 1) native soil, 2) 50% aged pine bark: 50% native soil, 3) 50% Mr. Natural™: 50% native soil, or 4) 100% Mr. Natural™. Mr. Natural™ consists of granite sand, expanded shale, and composted poultry litter. After two years, no differences in growth or survival existed. Study II: On 8 April 1992, trees were planted in 1) unamended planting holes, 2) tilled planting beds, or 3) tilled and pine bark-amended planting beds. Five

months after planting, the root growth in the tilled and tilled-amended beds did not differ, but both had more root growth than planting holes. Amendment-induced nitrogen deficiency reduced shoot growth of the tilled-amended treatment during the first year. After two years, the planting hole treatment exhibited the least shoot growth, while shoot growth of tilled and tilled-amended treatments did not differ. Study III: Selected trees in study II were drought stressed for 8 weeks beginning 4 August 1993. No differences in relative leaf water content among treatments were observed. Results suggest that native soil should be used as backfill in planting holes; however, tilling a planting bed increases root and shoot growth compared to planting in a hole. Amending beds with pine bark did not increase growth or drought tolerance.

103

EVALUATION OF COMPOSTS FOR PRODUCTION OF SOD-GROWN CROPS
Allen V. Barker* and Tara A. O'Brien, Plant and Soil Sciences
University of Massachusetts, Amherst, MA 01003

An agricultural compost of chicken manure and cranberry pomace, a municipal compost of biosolids and mixed municipal solid wastes, and a compost of autumn leaves were evaluated for production of turfgrass sods and wildflower sods. Composts made during the year of the experiment and one-year-old composts were compared. The experiment was conducted outdoors with composts layered on sheets of plastic laid on the soil surface. The sheets of plastic controlled soil-borne weeds and facilitated harvest of sods. The best sods measured by stand and growth were produced with the agricultural compost, which was rich in N (avg. 1.7%) and low in NH_4^+ (avg. 135 mg/kg). High NH_4^+ (>900 mg/kg) appeared to limit stand establishment with the fresh municipal compost. The leaf compost was too low in N to support sod growth without fertilization. Aging of each compost improved its capacity to support sod production, apparently as a result of changes in the N status in the media.

104

HORTICULTURAL USES FOR SEWAGE SLUDGE COMPOST
Robert F. Bevacqua*, Dept. of Parks, City & County of Honolulu, 650 S. King St., Honolulu, HI 96813
Valerie J. Mellano, Cooperative Extension, University of California, 5555 Overland Ave, Bldg 4, San Diego, CA 92123

Compost made from sewage sludge (40% by volume) and chipped trimmings of Eucalyptus trees (60%) was evaluated as a soil amendment for the field production of onion (*Allium cepa* cv. Spanish Sweet Utah), lettuce (*Lactuca sativa* cv. Black Seeded Simpson), snapdragon (*Antirrhinum majus* cv. Sonnet Yellow), and turfgrass (*Festuca arundinacea* cv. Marathon). Turf shows a strong response to preplant compost applications and is relatively tolerant of the buildup of soluble salts that can occur with compost applications. Also since it is not a food crop the possible uptake of heavy metals is not a major concern. These results indicate the amending of soil for the planting of turf is a likely commercial use of the compost. The authors are presently evaluating the use of the compost as a top dressing on turf plantings.

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PULSING MICROIRRIGATION IN CONTAINERS INCREASES TREE GROWTH
Richard C. Beeson, Jr.* CFREC-Sanford, 2700 E. Celery Ave., Sanford, FL 32771

Pulsing consists of applying subvolumes of a normal daily irrigation volume several times per day. Previous studies have shown splitting overhead irrigation into two subapplications increased growth of container-grown landscape ornamentals in the southeastern U.S. In Florida, water restrictions prohibit overhead irrigation during the critical mid-afternoon when irrigation is most beneficial. Using individual microirrigation spray stakes, only 25% of the water required for overhead irrigation per bed area was necessary to produce similar plants if irrigated once per day. When the same daily volume was pulsed as 2 or 3 subvolumes, tree growth was significantly increased. Data suggest 2 pulses are sufficient for trees with a xeric nature while mesic trees prefer 3 pulses per day. Root:shoot ratios were unchanged by pulsing. Lower cumulative diurnal water stress was measured on pulsed trees.

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INTERMITTENT SPRINKLER IRRIGATION AFFECTS PLANT GROWTH AND N LEACHING

Nabila S. Karam* and Alexander X. Niemiera, Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0327

The influence of intermittent and continuous irrigation on the growth, substrate nutrient accumulation and leaching from container-grown marigolds was determined. During a three week period, *Tagetes erecta* L. 'Apollo' in a pine bark substrate received 12 irrigations. Each irrigation allotment was applied intermittently (multiple applications) or continuously (single application). Irrigation occurred when bark reached a targeted water content; irrigation water contained a complete nutrient solution. Leachates were cumulatively collected for each container and analyzed for N; plant dry weight, size, and nutrient composition were determined. Compared to continuously irrigated plants, intermittently irrigated plants had 43% greater root dry weight, 0.7% greater N concentration, and 43% more N leached from the substrate. Shoot mass, size, K, and P concentrations, substrate (pour-through extraction) and leachate N concentration were unaffected by irrigation method. Results demonstrated that, compared to conventional irrigation practices, intermittent irrigation was an effective method to reduce fertilizer effluent and increase N absorption for container-grown plants.

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THE USE OF HYDROLYZED GRAIN PROTEINS AND DIPEPTIDES AS NATURAL NEED CONTROLS IN HORTICULTURAL CROPS
Nick E. Christians, and Dianna L. Liu, Iowa State University, Department of Horticulture, Ames, IA 50011

It has previously been reported that a byproduct of the corn (*Zeamays* L.) wet-milling process, corn gluten meal, has potential as a natural preemergence herbicide for use in turf and certain horticultural crops. In 1993, two additional patents were issued on the technology. The first is on the use of hydrolyzed proteins from corn and other grains that were shown to have higher levels of herbicidal activity than the corn gluten meal. These materials are water soluble and can be sprayed on the soils surface. The second patent was on 5 dipeptides extracted from the hydrolyzed corn gluten meal. These dipeptides were shown to have the same type of biological activity observed when the corn gluten meal and the hydrolyzed meal are applied to the soil. The possible use of the hydrolyzed grains and the dipeptides as natural preemergence herbicides in horticultural crops will be discussed.

53 ORAL SESSION 16 (Abstr. 109-115) Vegetables: Nutrition

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SIDE-DRESS CALCIUM FERTILIZATION INFLUENCE ON POTATO YIELD AND QUALITY.

George H. Clough, Oregon State University, Hermiston Agricultural Research and Extension Center, Box 105, Hermiston, OR 97838

Potato (*Solanum tuberosum*) cv. 'Russet Burbank' response to source of side-dress Ca fertilization applied at 0, 28 and 56 kg-ha⁻¹ Ca on fine sandy loam soil was evaluated. Side-dress Ca source and rate did not affect number or total weight of tubers/hill, average tuber weight, or tuber macronutrient concentrations at mid-season. Tuber B concentration was significantly greater with the 12-0-0-10.5 source as compared to the check. Tuber Fe concentration decreased linearly as 22-0-0-7 rate increased from 0 to 56 kg-ha⁻¹ Ca. No other micronutrient concentration was affected by the applied treatments. Calcium fertilization had no effect on tuber yield, grade distribution, or specific gravity. The predominant internal defect observed was brown center, which was reduced at harvest by side-dress Ca application. Internal quality and french fry color were evaluated after storage for 4 months.

WATERMELON PRODUCTION AS INFLUENCED BY LIME, GYPSUM, AND POTASSIUM RATE

S. J. Locascio* and G. J. Hochmuth, Horticultural Sciences Department, University of Florida, Gainesville, FL 32611

Watermelons [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] were grown with three rates each of lime, gypsum, and K during two seasons to evaluate their effects on fruit production and mineral concentration. The first experimental site was a recently cleared Sparr fine sand with an initial pH of 5.4 and Mehlich I extractable K of 32 ppm (low) and 948 ppm Ca. The second site was a virgin Pomona fine sand with a pH of 4.8, 28 ppm K, and 612 ppm Ca. 'Crimson Sweet' fruit yield was reduced 10% with an increase in lime rate from 0 to 4.48 Mt-ha⁻¹ in the first season. In the second season, lime rate had no effect on yield. In both seasons, fruit yields were reduced 14% by an increase in Ca from gypsum from 0 to 1.12 Mt-ha⁻¹. Fruit yields were not influenced by K rates from 90 to 224 kg-ha⁻¹. Application of lime and gypsum increased leaf tissue Ca concentrations and decreased K. An increase in K application significantly increased leaf K and decreased Mg in the first season but not significantly in the second season. Fruit firmness and soluble solid content were not consistently affected by treatment.

EFFECTS OF N SOURCE, APPLICATION FREQUENCY, AND SOIL NITRATE CONCENTRATION ON PEPPER YIELD AND QUALITY

K. (Dean) M. Batal, Horticulture Dept., University of Georgia, Coastal Plain Experiment Station, Tifton GA 31793-0748 USA

Various applications of N fertilizer formulations to bell pepper plots were made to affect soil nitrate-N concentrations from 5 to 30 ppm throughout the growing season. Number and weight of marketable grades for the 1st and 3rd harvests were improved by increasing soil N from 5 to 30 ppm. In the final (4th) harvest, marketable yield was highest for applications maintaining soil N of 25 ppm. Earliness was enhanced by N sources with Ca(NO₃)₂, producing the earliest yield followed by NaNO₃ and NH₄NO₃. Total marketable yield produced by Ca(NO₃)₂ or NaKNO₃ was 3 t/ha higher than by NH₄NO₃ applications. High marketable quality was maintained with Ca(NO₃)₂ and NaNO₃ treatments. The highest blossom-end rot (BER) incidence was associated with NH₄NO₃ applications. But the N source effect on BER was strongly influenced by soil nitrate levels. At 10-20 ppm soil N, leaf Ca decreased during the 8 to 12 week period, but at higher soil N, leaf Ca remained unchanged, indicating a constant Ca uptake during the critical growth period.

PRESIDEDRESS SOIL NITRATE TEST FOR SWEET CORN

J.R. Heckman*, D.J. Probstak, and W.T. Hlubik

Plant Sci. Dept., Lipman Hall, Cook College, New Brunswick, NJ 08903

The presidedress soil nitrate test (PSNT) is an in-season soil test that evaluates the N supplying capacity of soil before sidedressing to adjust N application rates. Increasing acceptance of this soil test among field corn growers in New Jersey has shown it to be an effective practice. Nitrogen application rates were reduced by an average of 45 kg ha⁻¹ without loss of crop yield. Field calibration research to extend use of the PSNT to sweet corn has the potential to improve N fertilizer recommendations for this crop. A critical concentration of 25 mg kg⁻¹ NO₃-N in the surface 30 cm of soil is generally considered adequate for field corn. Certain crop features of sweet corn (earlier harvest, smaller plant size and population) suggested that the critical NO₃-N level might be lower than for field corn while market quality suggested that it might be a higher value. Results from 40 sweet corn field calibration sites in New Jersey indicate that the PSNT critical soil NO₃-N concentration may be greater for sweet corn than field corn. A preliminary critical level of 30 mg kg⁻¹ NO₃-N in the surface 30 cm of soil is suggested for use of the PSNT on sweet corn. Further research is being conducted to improve sidedress N recommendations based on the PSNT.

ESTIMATING SOIL POTASSIUM SUPPLY TO MEET PROCESSING TOMATO REQUIREMENTS

T.K. Hartz, Department of Vegetable Crops, University of California, Davis, CA 95616

A 1993 survey of 50 commercial processing tomato fields in California revealed widespread potassium deficiency, as determined by tissue K levels below existing sufficiency standards and the occurrence of vine necrosis consistent with K deficiency. Soils from these fields were analyzed for exchangeable K by ammonium acetate extraction, and for K release rate by a 7 day incubation procedure (1:10 soil: .01 M CaCl₂ at 25°). Soil K release rate was more highly correlated with tissue K at midseason than was exchangeable K. These soils were further examined for K fixation capacity. Three g soil was blended with 3 ml 10 meq K as KNO₃, allowed to dry, incubated for 7 days in a 1:10 soil: H₂O solution, then extracted in 1 N NH₄Cl; added K not recovered was considered fixed. Percent K fixation ranged from 0 to 82%. These data suggest that the inconsistent response of processing tomato to K application in numerous California trials may be related to a) the reliance on extractable K analysis to characterize soil K supply and b) no consideration of soil K fixation capacity in determining K application timing and method.

CALIBRATING PLANT SAP QUICK TESTS FOR NO₃ AND K⁺ ON WINTER SNAP BEANS

Mary Lamberts*: Stephen K. O'Hair: George Hochmuth and Edward Hanlon, Dade Co. Coop. Ext. Serv., 18710 SW 288 St., Homestead, FL 33030; TREC, 18905 SW 280 St., Homestead, FL 33031; Dept. of Hort. Sci., U. of Fla., P.O. Box 110960, Gainesville, FL 32611 and Dept. of Soil & Water Sci., U. of Fla., P.O. Box 110510, Gainesville, FL 32611

Seventy-five percent (75%) of U.S. produced winter snap beans are grown on limestone soils in southern Dade County, Florida. Since this crop requires 60-70 days from planting to harvest, growers need information to make changes in fertilizer practices on an almost instantaneous basis. As part of a study to calibrate soil tests with yield responses to different levels of applied fertilizers, plant sap quick tests are being calibrated with laboratory analyses of whole leaf samples. Beans were grown at two locations -- in a grower's field and at the University of Florida Tropical Research & Education Center (TREC). Samples were taken simultaneously for both plant sap quick tests using petioles and for whole leaf tissue analyses. Results and how these have been extended to local growers will be presented.

EFFECT OF NITROGEN SOURCE AND LEVEL ON VEGETABLE AMARANTH

D. J. Makus, USDA, ARS, CPSR, Weslaco, TX 78956

On 3 Aug. 1993, 20-day-old 'Hinn Choy' plants (*Amaranthus tricolor* L.) were planted on 15 × 15 cm spacings in 4-row beds at 1.3 m row spacings in a Leadvale silt loam soil. Nitrogen sources of NH₄, NO₃, and NH₄NO₃ were used at rates of 0, 100 and 200 kg/ha, and were split-applied at and 1 week after transplanting. All treatments received both supplemental K and P at the rate of 90 kg/ha at planting. Plants were harvested 31 days after transplanting. Plants given the NH₄ source were taller, and were higher in yield, leaf chlorophyll, total carotenoids and Mn (dry wt basis) than were plants given other N-sources. NO₃-N fertilizer increased leaf Fe and Cu, and residual soil K and NO₃, but reduced Mn levels. Leaf blade Ca was highest when NH₄NO₃ fertilizer was used. Increasing N-rates decreased both soil pH linearly and leaf blade Ca but linearly increased soil EC, NO₃, and S and leaf blade N, K, S, P, NO₃, Fe, chlorophyll and carotenoids.

57 **ORAL SESSION 17 (Abstr. 116-123)**
**Tree Fruit and Berries: Gas Exchange/
 Photosynthesis**

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ANATOMICAL CHARACTERIZATION OF PHOTOSYNTHETIC CAPACITY OF EIGHT *Fragaria chiloensis* GENOTYPES

Paul W. Foote*, J. Scott Cameron and Stephen F. Klauer. Washington State University Research & Extension Unit, 1919 N.E. 78th St., Vancouver, WA 98665

Leaf-area based CO_2 assimilation rate (A_{LA} as an Indicator of genotypic differences in photosynthetic capacity is questioned on the basis of correlations found between A_{LA} and specific leaf weight and small leaf size. To address this question of photosynthetic apparatus concentration in *F. chiloensis* genotypes differing significantly in A_{LA} , visual image analysis software was used to quantify a number of leaf anatomy parameters. In 1991 and 1992, after gas exchange measurements in the field, leaf tissue was prepared in cross-sections and leaf clearings for light microscopy. Cross-sections were used to measure internal anatomical parameters and clearings for vein and stomatal densities.

Analysis of variance of 1991/92 measurements showed significant genotypic variation for leaf venation, leaf thickness, palisade cell length, cross-sectional area in mesophyll tissue and internal air space. Differences in stomatal density were observed in 1991. None of the anatomical parameters measured were correlated with A_{LA} . This suggests that the concentration of physical apparatus is not the major source of variation in A_{LA} among these eight genotypes.

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AN ANALYSIS OF STOMATAL v. NON-STOMATAL LIMITATIONS TO PHOTOSYNTHESIS IN RED RASPBERRY

Gina E. Fernandez and Marvin P. Pritts Dept. of Fruit and Vegetable Science, Cornell University, Ithaca, NY 14853

Stomatal and non-stomatal limitations to photosynthesis were determined for both primocanes and floricanes of "Titan" red raspberry. Limitations to photosynthesis were determined from the relationships between rates of photosynthesis (A), stomatal conductance (g), and the internal CO_2 concentration (C_i) of the leaf. We generated this data (A , g and C_i) using steady state gas exchange. Calculation of limitations were determined from A/C_i and A/g curves, second order polynomial regression and computer simulation. Using methods developed by Farquhar & Sharkey (1982), stomatal limitation during and after fruiting in both primocane and florican leaves was approximately 28%. Non-stomatal limitations were determined through computer modeling and expressed as the maximum rates of carboxylation, $V_{\text{c}_{\text{max}}}$, and of electron transport, J_{max} .

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ACTUAL AND SIMULATED MITE-FEEDING EFFECTS ON TART CHERRY PHOTOSYNTHESIS IN THE FIELD

Mark A. Hubbard*, James A. Flore, John C. Wise and James W. Johnson. Departments of Horticulture and Entomology, Michigan State University, East Lansing, MI 48824-1325

European red mite (*Panonychus ulmi*) populations were monitored in a tart cherry (*Prunus cerasus* 'Montmorency') orchard and the effects on photosynthesis determined. Mites levels were controlled in some trees by miticide applications to establish different cumulative mite*days in the trees. Photosynthetic inhibition caused by insect injury was also simulated by spraying other trees with 78 ppm Terbacil at one of four different times during the season. The mite*days accumulated in 1993 ranged from 937 to 2205, however, there were no differences in single leaf or whole tree CO_2 assimilation, chlorophyll a fluorescence, or chlorophyll levels among the different levels of mite damage. Likewise, there were no differences in these same parameters among the Terbacil-treated trees except that photosynthesis was reduced on treated trees for 10-14 days, after which photosynthesis recovered to the level of the controls. There were no differences in yield or fruit quality among any treatments, and cold hardiness and return fruiting characteristics will be measured.

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PHOTOSYNTHESIS AND RESPIRATION OF APPLE PLANTS AT DIFFERENT CARBON DIOXIDE CONCENTRATIONS

Qiyuan Pan* and Bruno Quebdeaux, Department of Horticulture, University of Maryland, College Park, Maryland 20742-5611

Low CO_2 concentrations ($[\text{CO}_2]$) frequently occur in dense crop canopy. To determine plant performance under sub-atmospheric $[\text{CO}_2]$, young 'Gala' apple plants were phytotron-grown at 928 $\mu\text{mol m}^{-2}\text{s}^{-1}$ light intensity. Whole-plant photosynthesis and respiration under $[\text{CO}_2]$ between 0 and the ambient level (382 to 460 $\mu\text{mol l}^{-1}$) were measured by monitoring $[\text{CO}_2]$ of the air entering and coming out of a 38-l clear plexiglass gas exchange chamber at either 3.4 or 6.2 l min^{-1} . The chamber seals two plants of up to 77 cm height for long-term experiments. There was a linear relationship between $[\text{CO}_2]$ and net photosynthesis (P_n), with the R^2 being as high as 0.99. The increase of P_n with increased $[\text{CO}_2]$ was 51% greater for the high air flow than for the low air flow. At the ambient CO_2 level P_n at the high flow rate was 49% higher than that at the low flow rate. CO_2 compensation points were 57.6 and 58.5 $\mu\text{mol l}^{-1}$ at the high and low flow rates, respectively. The relationship between $[\text{CO}_2]$ and dark respiration was linear. Dark respiration decreased by 20% on average as the $[\text{CO}_2]$ increased from 0 to the ambient level, and it was 11% higher at the high flow rate than at the low flow rate. These results suggest that wind may act to reduce P_n depression in dense crop canopy by both reducing leaf resistance and atmospheric $[\text{CO}_2]$ gradient outside the boundary layer.

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RESPIRATORY CHANGES IN APPLE VEGETATIVE BUDS AND INTERNODES DURING BUDBREAK

Tania K. Dautlick* and Eric Young, Department of Horticultural Science, North Carolina State University, Box 7609, Raleigh, NC 27695-7609

One-year-old potted 'Jonagold' apple trees on M.9 EMLA rootstock were chilled in a cold room at 5°C for 1320, 3288 or 4464 hours. They were then placed in a 22°C greenhouse for forcing. Rate of dark respiration of buds and internodes was measured in vivo using the LICOR LI 6200 portable photosynthesis system. Measurements were taken on each tree at several distances from the shoot apex during the forcing period. The new apical growth was removed from half of the trees when apical growth was 2-4 cm. Removal of apical growth did not appear to influence respiration. Respiration of both buds and internodes generally decreased with distance from apex. As budbreak occurred or when trees received excess chilling hours, the effect of distance from apex on respiration decreased. Excess chilling also resulted in greater and more rapid budbreak.

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TREE GROWTH, LEAF NITROGEN, NET GAS EXCHANGE, AND CARBON ISOTOPE DISCRIMINATION IN CITRUS

Jim Syvertsen* J. Lloyd² and G.D. Farquhar², ¹Univ. Fla., CREC, Lake Alfred, FL, USA and ²Australian National University, RSBS-PEB, Canberra, ACT, 2601, Australia

Four to six-yr-old 'Red Ruby' grapefruit trees on either 'Volkamer' lemon (VL) or sour orange (SO) rootstocks were fertilized with 3 rates of nitrogen (N) over a 3 year period. We studied the effects of leaf N concentration on stomatal conductance (g), net assimilation (A) of CO_2 (LI-Cor portable gas exchange system), carbon isotope discrimination ($\delta^{13}\text{C}$) of tree tissues, root growth, canopy development and fruit yield. Using springtime measurements of net gas exchange during the fifth year, g , A and leaf tissue $\delta^{13}\text{C}$ were positively correlated with leaf N. The faster growing trees on VL had larger canopy volumes and fruit yields but lower leaf N, A and $\delta^{13}\text{C}$ than those on SO. Thus $\delta^{13}\text{C}$ was positively correlated with A but negatively related to tree size and yield. By the sixth year, $\delta^{13}\text{C}$ was still related to N but tree growth had apparently obscured any rootstock effects on leaf N, water use efficiency, A and $\delta^{13}\text{C}$. Leaf and trunk bark tissue $\delta^{13}\text{C}$ did not differ but root bark had lowest $\delta^{13}\text{C}$ regardless of rootstock species.

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THE INTERACTION OF TEMPERATURE AND VAM FUNGI ON DIURNAL LEAF GAS EXCHANGE OF 'EUREKA' LEMON TREES

Chris A. Martin*, Jean C. Stutx and Richard L. Garcia, Department of Botany, Arizona State University, Tempe, AZ 85287-1601

Eureka lemon (*Citrus limon* L. 'Eureka') trees were inoculated with ecotypes of VAM fungi isolated from either a subtropical desert (HVAM) or a temperate grassland (LVAM), and grown for five months at 40.5°C/32.2°C (high) or 29.4°C/21.1°C (low) day/night, respectively. Diurnal measurements of leaf carbon assimilation (A), transpiration (E) and stomatal conductance (g_s) were then made with a portable photosynthesis system. At high temperatures, afternoon A , E and g_s were highest for trees inoculated with

LVAM and lowest for trees inoculated with HVAM. At low temperatures, afternoon A, E and gs were highest for trees inoculated with HVAM and lowest for trees inoculated with LVAM. Compared to controls, trees inoculated with HVAM and LVAM displayed rapid mid-day fluctuations in stomatal conductance. At low temperatures, water use efficiency (WUE) during the morning was lowest for trees inoculated with LVAM; whereas, afternoon WUE was not affected by HVAM or LVAM. HVAM and LVAM did not affect WUE at high temperatures. Results indicate that long-term physiological adaptations of lemon trees to temperature are uniquely affected by different VAM fungal ecotypes.

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MOVEMENT PROTECTS CARAMBOLA LEAFLETS FROM HIGH LIGHT AND TEMPERATURE STRESS

Thomas E. Marler and Patrick J. Lawton, College of Agriculture & Life Sciences, University of Guam, UOG Station, Mangilao, Guam 96923

Leaflets of carambola were restricted to a horizontal position for 3.5-h during late morning and early afternoon on sunny days to determine the influence of natural leaflet movement on temperature and chlorophyll fluorescence. Adaxial temperature of these horizontal leaflets was 5-9 C higher than that of leaflets that were allowed to move in response to high light. Chlorophyll fluorescence was similarly affected. Leaflets that were allowed to move had a higher F/F_m than leaflets that were restricted in movement. The results indicate that the presence of a pulvinus at the base of each leaflet of carambola leaves allows movement of the leaflet to avoid incident light. This natural leaflet movement under sunny conditions results in a lower temperature and a higher level of photochemical efficiency when compared with leaflets that are exposed to high light due to restricting their movement.

0.5 mM silver thiosulfate (STS), an ethylene-action inhibitor, or water (as a control) every 2 days. Specific 'target' leaflets, 5-10 mm in length at the beginning of the constant-light period, were harvested on days 5-9 of constant light, during injury development, and placed in bags made of Teflon film for 10-15 minutes to collect ethylene. Ethylene release and necrotic spotting increased as days of constant light increased for both water and STS-treated leaves, though STS-treated leaves produced slightly less ethylene and significantly less necrotic spotting than water-treated leaves. Ethylene release was correlated with extent of necrotic spotting. STS-treated plants exhibited greater dry weight and leaf area than water-treated plants. The results indicate that ethylene is not only produced by injured leaf tissue but, in addition, that ethylene may have a role in the development of constant-light injury symptoms.

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THE RELATION OF PEPPER FLOWER AND FLOWER BUD ABSCISSION WITH BUD CARBOHYDRATE AND ACC CONTENT

H. C. Wien* and A. D. Turner, Dept. of Fruit and Vegetable Science, Cornell University, Ithaca, New York. 14853

When bell pepper plants are subjected to high temperatures or low irradiance during flowering, abscission of flowers and flower buds can be severe enough to limit yields. Both types of stresses may lead to reduction of carbohydrate levels in the reproductive structures, and evolution of the abscission-causing hormone ethylene. In two greenhouse experiments, plants were subjected to combinations of 30 or 20 C air temperature and unshaded or heavily shaded conditions for one week at anthesis of the first flower. In a third experiment, plants were subjected to total darkness and temperatures of 30, 20 or 15 C for one week at the same stage of growth. In all experiments, levels of soluble carbohydrates and starch declined under low or zero light conditions, with rate of decrease proportional to the air temperature. Abscission of reproductive structures was not well correlated with carbohydrate levels: in spite of low sugars and starch, plants darkened for 7 days at 15 C showed no abscission. Levels of the ethylene precursor ACC in the buds, though variable, rose just before abscission began, but remained low in non-abscising treatments.

58 ORAL SESSION 18 (Abstr. 124-131) Vegetables: Stress

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VEGETABLE CROP RESPONSE TO SOIL COMPACTION

David W. Wolfe Department of Fruit & Vegetable Science, Cornell University, Ithaca, NY 14853

Field studies conducted in 1993 on an Eel loam soil compared the growth and yield response of direct-seeded cabbage, cucumber, snap bean, and sweet corn, and transplanted cabbage, to a compacted soil layer (>2.5 MPa penetrometer resistance) at the 15 - 30 cm depth. Direct-seeded cabbage and snap bean were most severely affected by compaction, with 50% yield losses, and much smaller cabbage head size in compacted plots. Transplanted cabbage had a 30% lower yield in compacted compared to uncompacted plots. Early vegetative growth of cucumber was less stunted by compaction compared to snap bean and cabbage, but compaction nevertheless resulted in a 50% reduction in total cucumber yield. Compaction delayed maturity and reduced early yield of cabbage, snap bean, and cucumber. Sweet corn yield was reduced by only 10% when grown on compacted soil, and there was no delay in maturity. Sweet corn responded more negatively to compaction in a 1992 field experiment.

Greenhouse studies found a reduction in total plant biomass at 21 days after planting of 30%, 14%, 1%, and 3% for snap bean, cabbage, cucumber, and sweet corn, respectively, in pots compacted at the 10 cm depth. Sweet corn had a significantly higher proportion of root biomass in the compacted zone compared to the other crops. For all species, the growth reductions could not be attributed to reductions in leaf turgor, photosynthetic rate per unit leaf area or leaf nutrient status.

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STEM PITH TISSUE FREEZING RESISTANCE IN CABBAGE (*BRASSICA OLERACEA* VAR. *CAPITATA*)

Reeser C. Manley * and Rita L. Hummel, Washington State University-Puyallup, Puyallup, WA 98371

Winter survival of cabbage seed crops is limited by the freezing resistance of the lower stem pith tissue. Both tolerance of extracellular freezing and avoidance of lethal temperatures are components of stem pith tissue freezing resistance. The avoidance mechanism involves the formation of ice within the pith tissue at relatively warm temperatures (little undercooling) and the subsequent release of heat of fusion, followed by significant slowing of the freezing rate so that stem temperatures are mitigated against ambient temperatures for several hours.

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POLLEN CHARACTERISTICS AND *IN VITRO* POLLEN GERMINATION OF TOMATOES GROWN AT HIGH NIGHT TEMPERATURES

Mary M. Peet*, Daniel H. Willits and Michael Bartholomew, Departments of Horticultural Science and Biological and Agricultural Engineering, North Carolina State University, Raleigh, NC 27695-7609.

Previous greenhouse studies in Raleigh have shown that nighttime cooling increases tomato fruit weights from 11% to 53%, depending on planting dates. The physiological mechanism was unclear, except that temperatures during fruitset were most critical. We report here on 3 experiments, 2 in greenhouses and 1 in the phytotron, comparing pollen characteristics of plants grown at differing night temperatures. In the greenhouse studies, nighttime temperatures were kept below 20°C for either the whole night or just the last half of the night. In the phytotron studies night temperatures were 18, 22, 24 or 26°C. In both phytotron and greenhouse studies, there was considerable day-to-day variability in pollen characteristics and % germination. The most consistent effect in both types of studies was a decrease in total pollen and an increase in % abnormal pollen at high night temperatures. In the phytotron studies 20°C appeared optimal for both these characteristics.

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THE ROLE OF ETHYLENE IN THE DEVELOPMENT OF CONSTANT-LIGHT INJURY OF POTATO

K. E. Cushman* and T. W. Tibbitts, Univ. of Wisc., Madison, WI 53706

Chlorosis and necrotic spotting develop on expanding leaves of particular cultivars of potato (*Solanum tuberosum* L.) when grown under constant light and temperature conditions. Plantlets of a constant-light sensitive cultivar, Kennebec, were planted into peat:vermiculite and established at 18C for 10 d under a 12 h light: 12 h dark photoperiod. Plants were then exposed to constant light and sprayed with 1 ml of either

EFFECT OF CHILLING ON RESPIRATION AND INDUCTION OF CYANIDE-RESISTANT RESPIRATION IN CUCUMBER AND PEA ROOTS. Eleazar Reyes and Paul H. Jennings. Department of Horticulture and Recreation Resources. Kansas State University, Manhattan, KS. 66506.

The effect of chilling stress on respiration and induction of the cyanide-resistant pathway was investigated using roots of cucumber and pea grown at 26°C and 23°C and exposed to 2°C, 10°C or 15°C for either 24 or 96h. Oxygen uptake of 2°C treated cucumber roots decreased between 24 and 96 h of chilling and then dramatically increased between 96 and 192h. The cyanide-resistant pathway did not change in cucumber roots at 10°C or 15°C for 24h or 96h, nor after a 24h recovery period at 26°C. At 2°C, cyanide resistant O₂ uptake increased during the 24h recovery period following a 24h chilling but not after 96h chilling. Cyanide resistant oxygen uptake in pea roots was unaffected by 10°C and 15°C for 24h or 96h and a 24h recovery at 23°C. At 2°C, no effect in cyanide resistant O₂ uptake was observed by 24h chilling but a significant increase occurred after 96h which returned to pre-stress levels with a 24h recovery at 23°C.

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SUPEROXIDE PRODUCTION BY MITOCHONDRIA ISOLATED FROM CHILLING-SENSITIVE PLANT TISSUE

A. C. Purvis* and R. L. Shewfelt, Univ. of Georgia, Dept. of Hort., CPES, Tifton, GA 31793 and CFSQ, Georgia Station, Griffin, GA 30223-1797.

An emerging theory contends that chilling injury is due to oxidative damage resulting from the metabolic generation of active oxygen species. Mitochondria were isolated from chilling-sensitive (CS) and from conditioned chilling-resistant (CR) bell pepper fruit and their ability to generate superoxide determined by measuring the formation of adrenochrome from epinephrine. Mitochondria from CS fruit were sensitive to cyanide and produced superoxide when supplied with NADH, succinate, or malate-pyruvate. Mitochondria from CR fruit were insensitive to cyanide and sensitive to SHAM and produced little superoxide when supplied with respiratory substrates. ATP enhanced the production of superoxide and ADP reduced the production. Results suggest that the mitochondria are a major source of superoxide in CS plant tissue and the presence of the alternative pathway reduces the production of superoxide.

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PEROXIDATIVE CHALLENGE OF PLASMA MEMBRANE VESICLES FROM BELL PEPPER FRUIT LEADS TO DECREASED H⁺ATPase ACTIVITY

Darlene M. Cowart and Robert L. Shewfelt*, Center for Food Safety and Quality Enhancement, University of Georgia, Griffin, GA 30223-1797

Lipid peroxidation has been proposed as an important factor in chilling injury of susceptible fruits and vegetables. The effect of *in vitro* peroxidative challenge on H⁺ATPase activity in intact plasma membrane vesicles and solubilized enzyme was determined by incubation with (1) deionized water (control), (2) Fe³⁺-ascorbate, and (3) lipoxygenase (LOX) + phospholipase A₂ (PLA₂) for 0, 30, and 60 min. Enzyme activity increased throughout the incubation period with no accumulation of thiobarbituric acid-reactive substances (TBA-RS) in the control, but vesicles challenged by the peroxidative systems showed significant increases in TBA-RS and decreases in membrane-bound H⁺ATPase activity. Greater losses in H⁺ATPase activity were observed in solubilized enzyme than in intact vesicles. The results indicate that loss of H⁺ATPase activity due to chemical modification of the protein rather than changes in membrane fluidity and suggest that modification is away from the active site.

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ORAL SESSION 19 (Abstr. 132-139) Cross-commodity: Postharvest

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A PERMEABLE MEMBRANE RESPIROMETER

Randolph M. Beaudry* and Niti Dube, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

The dynamic physiological processes of CO₂ production, O₂ uptake and ethylene synthesis for ripening tomato (*Lycopersicon esculentum* L.) and banana (*Musa* sp. cv 'Valery') fruit were measured using a novel approach. Fruit were sealed in low density polyethylene pouches of known permeability to O₂, CO₂ and C₂H₄. The flux of these gases during the climacteric was closely tracked by their respective partial pressure in the headspace of the pouches. Some limitations in application exist due to modification of the atmosphere (primarily O₂) within the pouch, however, the system provides some distinct advantages. These include the absence of gas handling equipment, measurement of O₂ uptake despite high background levels of O₂, measurement of the respiratory quotient, and measurement of low rates of ethylene production. Compared to low-flow, flow-through respirometers, this type of respirometer has the potential to permit the accumulation of several-fold higher levels of some gases due to the property of differential gas permeabilities possessed by polymer films.

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MODIFIED-ATMOSPHERE PACKAGING OF LIGHTLY PROCESSED APPLE FRUIT: PACKAGE OXYGEN PERMEABILITY REQUIREMENTS

Ruomwadee Lakakul*, Randolph M. Beaudry and Ruben J. Hernandez, School of Packaging (RL and RJH) and Horticulture Department (RMB), Michigan State University, East Lansing, MI 48824.

Reduced O₂ and elevated CO₂ atmospheres have the potential to control browning, decay and texture changes in sliced apples. Modified-atmosphere packaging (MAP) was used as a tool for obtaining respiratory data needed to calculate permeability characteristics of packaging films that will obtain and maintain target gas levels in the package headspace at 0, 5, 10 and 15°C. Respiratory data collected for sliced apple fruit include the K_{1/2} (the O₂ level at the half-maximal respiratory rate), RR_{O_{2max}} (the maximal respiratory rate) and the Lower O₂ limit for aerobic respiration. The K_{1/2} and RR_{O_{2max}} appeared to increase exponentially with temperature. The lower O₂ limit was approximately 0.1, 0.2, 0.3 and 0.35 kPa at 0, 5, 10 and 15°C, respectively. Permeability characteristics needed for various storage strategies were calculated based on these data.

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A NOVEL TECHNIQUE TO MODULATE OXYGEN DIFFUSION IN BANANA FLESH

Rufino Perez* and Randolph M. Beaudry, Postharvest Physiology Laboratory, Horticulture Department, Michigan State University, East Lansing, MI 48824.

Oxygen diffusive resistance of preclimacteric banana flesh is considered to be much lower than skin resistance such that negligible internal gradients in O₂ are expected. Therefore, blocking O₂ influx and CO₂ efflux of banana by sealing 100% of the pores over fractions of one 1/4, 1/2, 3/4, and 7/8 of the surface, should generate an internal modified atmosphere similar to that achieved by using fruit coatings which cover 100% of banana surface but block only a fraction of the pores. Using gas trapping vials to determine internal O₂ and CO₂ levels, we followed O₂ and CO₂ behavior along the length of the fruit. Gradients for O₂ and CO₂ were found indicating sufficient flesh resistance exists to prevent consideration of internal resistances as negligible. Internal gas gradients were linked to ripening in that firmness and greenness were higher at the coated end. These results imply that banana flesh can not be treated according to the hollow sphere models previously suggested.

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LOW TEMPERATURES AND CONTROLLED ATMOSPHERES MAINTAIN QUALITY OF FRESH CUT BELL PEPPER

Rawia El-Bassuoni and Marita Cantwell,* Agricultural Research Center, Giza, Egypt and Dept. Vegetable Crops, Univ. California, Davis 95616

Bell pepper fruits (green and red) were stored intact or prepared in dices (1 x 1 cm), washed with chlorinated water, blotted, and stored in air or controlled atmospheres (air or 3% O₂ with 0, 5 or 10% CO₂) at 0, 5 or 10°C for up to 20 days. Dicing resulted in respiration rates 2-3 times higher than those of intact peppers, but did not result in measurable increases in ethylene production. Samples were periodically transferred to 15°C for 12 h before evaluation for visual quality, decay, discoloration, aroma, flavor, texture, and sugar content. Quality changes were similar for green and red fruit of the same cultivar. Intact peppers are chilling sensitive, but the quality of diced peppers was maintained best at 0°C. The shelf-life of diced pepper at 10 and 5°C was 1/2 to 2/3 that of intact peppers. Atmospheres containing 5 or 10% CO₂ reduced decay and increased the shelf-life of diced peppers, but were not as effective as storage in air at 0°C. Storage at 0°C also resulted in greater retention of sugars than storage under other conditions. High CO₂ atmospheres resulted in softening of pepper tissue and increased electrolyte leakage. Aroma and flavor scores declined more rapidly in CA than in air storage.

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DIFFERENTIAL SCANNING CALORIMETRY (DSC) OF AVOCADO AND MANGO FRUITS STORED IN AN INSECTICIDAL ATMOSPHERE
 Elbadi M. Yahia* and Marisela Rivera Dominguez, Centro de Investigación en Alimentación y Desarrollo, Apartado Postal 1735, Hermosillo, Sonora, 83000, Mexico.

Modified and controlled atmospheres with $\leq 0.5\%$ O₂ and/or $\geq 50\%$ CO₂ are insecticidal. In previous studies we have found that avocado is very sensitive and mango is very tolerant to these atmospheres. We used DSC to study the differences in response between these two fruits, and to relate that with their sensitivity/tolerance to hypoxia. Fresh or lyophilized tissues of fruits stored in air or in an insecticidal atmosphere were scanned at a temperature range of 10 to 145°C at a rate of 10°C/min. There were qualitative and quantitative differences between thermograms. There were fewer endotherms in thermograms of fresh tissue samples than in lyophilized tissue samples. Avocado thermograms showed a major endotherm at ca 15°C and 2 minor endotherms at ca 105-110°C. In addition, mango heating thermograms showed another major endotherm at ca 80°C. This endotherm was not present in the heating thermograms of avocado, and might represent a contributing factor in the tolerance of mango to insecticidal atmospheres.

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POSTHARVEST DELAY OF MUSKMELON FRUIT MEMBRANE SENESCENCE BY CALCIUM

Gene Lester, USDA, ARS, Crop Quality and Fruit Insects Research, 2301 S. Intl. Blvd., Weslaco, TX 78596

Hypodermal mesocarp disks from abscised muskmelon fruits (*Cucumis melo* L. var. *reticulatus* Naud.) were floated in 0.00, 0.04 or 0.16 M CaCl₂ plus 0.35 M mannitol at 20°C in the dark for 10 days. Changes in chlorophyll, protein and total phospholipids all indicators of membrane senescence were assayed. The catabolism, percent retention, of chlorophyll, protein and total phospholipids was delayed by 0.04 M Ca, but accelerated by 0.16 M compared to no Ca. Loss of membrane integrity, increased free sterol: total phospholipid (umol./umol.), was delayed by 0.04 M Ca, but accelerated by 0.16 M compared to no Ca. The degree of lipid saturation was inconclusive between Ca treatments. Muskmelon fruit disks membrane lipid degradation is slowed by 0.04 M Ca but accelerated by supraoptimal 0.16 M Ca treatment.

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LIPID CHANGES IN TOMATO FRUIT MICROSOMAL MEMBRANES DURING RIPENING

Bruce D. Whitaker, Horticultural Crops Quality Laboratory, Agricultural Research Service, USW, Beltsville, MD 20705

A previous study of lipids from pericarp tissue of tomato fruit ranging from mature-green to red-ripe showed a large increase in total sterols accompanied by dramatic changes in sterol composition and conjugation with ripening. This study was conducted to determine whether similar changes occur in microsomal membranes derived from tomato fruit pericarp. Acylated sterol glycoside (ASG), the predominant sterol lipid, declined during ripening, with increases in sterol glycoside (SG) and free sterol (FS). Only minor changes in fatty acid composition were associated with the drop in ASG. The stigmastanol:sterol ratio increased

throughout ripening, but much more in FS than in SG or ASG. The ratio of FS to phospholipid (PL) increased with ripening. However, FS was never greater than 10 percent of the total membrane sterol (TMS), and TMS:PL actually declined over the middle stages of ripening. It is not known why tomato tissues maintain such high levels of ASG and SG, but sterol conjugation is thought to regulate the physical properties of cell membranes.

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STABILITY OF MICROSOMAL AND MITOCHONDRIAL MEMBRANES AGAINST PEROXIDATIVE ATTACK

Brenda A. del Rosario* and Robert L. Shewfelt, CFSQE, University of Georgia, Griffin, GA, 30223-1797 and Albert C. Purvis, Dept. of Horticulture, CPES, University of Georgia, Tifton, GA, 31793

Evidence is accumulating that mitochondria possess defense mechanisms which effectively protect component membranes from the attack by active oxygen species which are produced continuously within the organelle. This study compared the stability of microsomal (from bell pepper fruit pericarp and cauliflower florets) and mitochondrial (from bell pepper fruit pericarp) membranes against peroxidative challenge systems (cumene hydroperoxide and iron-ascorbate). Protein concentration, (l-tocopherol levels, and total lipids were observed to decrease for both membranes when challenged. The onset of peroxidation was observed to be earlier and at higher levels in microsomes than in mitochondria. These results demonstrate the increased stability of mitochondrial membrane fractions to peroxidative challenge and suggest that the level of antioxidants and not fatty acid composition is the critical factor in resistance to oxidative stress in plant mitochondria.

71 ORAL SESSION 20 (Abstr. 140-146) Postharvest: Apple and Pear

140
DEVELOPMENT OF SUPERFICIAL SCALD ON 'D'ANJOU' PEARS DURING COLD STORAGE AS INFLUENCED BY GROWING ELEVATION

Paul M. Chen* and Diane M. Varga, Mid-Columbia Agric. Res/Ext Center, Oregon State University, 3005 Experiment Station Dr., Hood River, OR 97031

'D'Anjou' pears (*Pyrus communis*, L.) growing in 3 locations with the elevation at 150 meters, 380 meters, and 610 meters respectively in Hood River valley, Oregon were harvested at the commercial maturity with the flesh firmness of 62.3 Newton (± 2.2 N) and stored in air at -1°C. Regardless of different growing elevations, the incidence of superficial scald became noticeable after 2.5 months of storage and became substantial after 3 months. The rate of scald development was higher on the fruit from 150 meters elevation than those from higher elevations. Alpha-farnesene and conjugated trienes in the peel tissue accumulated at faster and higher rates in the fruit from 380 meters and 610 meters elevations than those from 150 meter elevation. The threshold level of conjugated trienes which causes superficial scald disorder was different from the fruit grown at different elevations.

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MULTIVARIATE STATISTICAL ANALYSIS: AN APPROACH TO ASSESS 'GALA' APPLE QUALITY.

A. Plotto*, A.N. Azarenko, and M.R. McDaniel, Departments of Horticulture, and Food Science and Technology, Oregon State University, Corvallis, OR 97331, and J.P. Mattheis, USDA-ARS, 1104 N. Western Ave, Wenatchee, WA 98801.

'Gala' apples were harvested at weekly intervals for 6 weeks, refrigerated at 0°C, and evaluated by a consumer panel monthly over a 6 month period for overall liking, firmness, sweetness, tartness and flavor intensities. Firmness, titratable acidity and soluble solids concentration were also measured. Initial analysis of sensory data revealed multicollinearity for overall liking, sweetness, and flavor. The five descriptors explained 75 % of the dataset variation in the first two factors. An

orthogonal rotation separated overall liking, flavor and sweetness, and firmness and tartness into two independent factors. The distribution of mean scores along these independent factors showed that panelists could perceive changes due to ripening and maturation. The multivariate factor analysis was better than univariate ANOVA at illustrating how apple maturity stages were apparent to untrained panelists. Firmness was the only instrumental variable correlated to firmness ratings in the sensory tests. None of the analytical measurements could explain overall liking.

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ESTER FORMATION IN RELATION TO HARVEST MATURITY AND CONTROLLED-ATMOSPHERE STORAGE OF 'GALA' APPLES

J. K. Fellman*, D.S. Mattinson Plant Science Division, University of Idaho, Moscow ID 83844-2339, James P. Mattheis, D.A. Buchanan USDA/ARS Wenatchee WA

Volatile esters from acids and alcohols are important components of flavor and odor perception in apples (*Malus domestica* Borkh.). We are interested in understanding the biochemical basis for ester synthesis/flavor retention in 'Gala' apples held in controlled atmosphere storage. The relationship between acetyl CoA alcohol transferase (AAT) acetate ester-formin activity, non-ethylene volatile emission, and flesh volatile content of 'Gala' apples during the maturation period and after removal from CA storage was investigated. At the appropriate times, apples were sampled for volatile compounds in the headspace and flesh using solid sorbent along with purge-and-trap capillary gas chromatography. Subsequently, acetate ester forming activity was assayed on partially-purified extracts of cortical tissue. During storage, the accumulation of the major flavor notes butyl acetate and 2-methyl butyl acetate in the flesh was decreased as oxygen levels in storage atmospheres were lowered. AAT activity is closely linked to the onset of climacteric ripening and is sensitive to atmospheres having low oxygen contents.

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COLOR AND QUALITY OF 'DELICIOUS' APPLES BY DELAYED HARVEST DATE AND CONTROLLED-ATMOSPHERE STORAGE

S.R. Drake*, USDA, ARS, Tree Fruit Research Laboratory, Wenatchee, WA 98801 and Tom Eisele, Tree Top, Inc., Selah, WA 98942

Red color of 2 strains ('Bisbee' and 'Red Chief') of 'Delicious' apples was increased (25%) by a 10 day delay beyond recommended harvest date. Color of 'Oregon Spur' did not change during this 10 day period. Soluble solids content and size were also increased, but firmness decreased by 12%. In 2 of 3 years, firmness at harvest was 73 N or greater in all strains and these fruit lost little firmness during 9 months of CA. Poor firmness (<63 N) at harvest resulted in fruit with unacceptable firmness (53 N) after storage regardless of harvest time or strain. Loss in fruit quality was evident after a 5 day delay in atmosphere establishment with no further loss after a 10 day delay. 'Oregon Spur' had the best color regardless of harvest, followed by 'Bisbee' and 'Red Chief'. All strains ('Oregon Spur', 'Bisbee' and 'Red Chief') had good quality after long term CA. Sensory panelists could not distinguish flavor differences between strains, harvest dates or delay in storage establishment.

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INFLUENCE OF ROOTSTOCKS AND CALCIUM SPRAY RATES, TIMING, AND MATERIALS ON SPRAY INJURY AND FRUIT QUALITY OF 'DELICIOUS' APPLES

J. Thomas Raese* and S.R. Drake, USDA, ARS, Tree Fruit Research Laboratory, Wenatchee, Washington 98801

Sprays of calcium materials were applied at high volume rates (620 g Ca/400 liters) with a handgun during early June, late June, and mid-July versus mid-July, early August, and late August for five years, 1985 to 1989. Leaf injury was most severe for the late sprays but no spray injury was observed on the fruit surfaces. Bitter pit was markedly reduced with all sprays except CaSO₄. In some years, bitter pit was controlled better with the early sprays. Either early or late sprays improved fruit quality including overall appearance, reduced scald development, improved red color of the skin, increased fruit firmness and reduced incidence of bitter pit in cold air (0°C) storage. Soluble solids and acidity in the fruit was not affected by calcium sprays. Leaf Ca was higher from the late spray applications than from the earlier applications. All calcium chloride spray materials resulted

in increased fruit peel and cortex Ca. Calcium nitrate sprays tended to increase fruit nitrogen concentrations leading to undesirable higher N:Ca ratios in the fruit.

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IS DIPHENYLAMINE A NATURAL PRODUCT IN APPLES?

William J. Bramlage*, Zhiguo Ju, Dept. of Plant and Soil Sciences, and Thomas L. Potter, Agr. Expt. Station Mass Spec. Lab., University of Massachusetts, Amherst, MA 01003-0910

Diphenylamine (DPA) is applied postharvest to apples and pears to control scald development after storage. Using GC-MS analyses of hexane extracts of fruit surfaces, about 0.1 ug/g of DPA was measured on apples after 7 months of storage, even though no fruit in the storage were treated with DPA. Residues also were present on walls in the storage rooms. There is a report that DPA can be produced in plants. Therefore, fruit of 5 cvs. were harvested in mid-August and at commercial maturity and immediately extracted for measurement. A signal similar to that of DPA was detected in all extracts, but concentrations were too low for positive identification. Results show that presence of DPA residue on stored fruit is not proof that DPA was applied before storage. Extracts from freshly harvested fruit are being concentrated to try to ascertain the identity of the indicated material(s).

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STORABILITY OF APPLES DAMAGED BY TUFTED APPLE BUD MOTH

C. L. Barden*, G. M. Greene and L. A. Hull, Dept of Horticulture and Entomology, Penn State Univ. Fruit Research Lab. P.O. Box 309, Biglerville, PA 17307

In the 1992-93 experiments tufted apple bud moth (TABM) damage generally had little effect on at-harvest maturity/quality indices of 'Golden Delicious', 'Delicious' or 'York Imperial' apples. However, at harvest starch scores of 'Golden Delicious' and the soluble solids (SS) of 'York Imperial' were higher in fruit with TABM damage. Following storage however, there were little or no effects of TABM damage on firmness or SS in any of the 3 cultivars. Percent decay was 0 and 18% in 'Golden Delicious' and 2 and 6% in 'Delicious' for control fruit and those with the most TABM damage (> 10 mm aggregate diameter), respectively. These were significant linear relationships - R² = 0.41 and 0.12 for 'Golden Delicious' and 'Delicious', respectively. Weight loss increased by 2-3 fold in the apples in the highest damage category. These results show that the post-storage quality of apples with slight TABM damage did not differ from that of undamaged fruit. Good CA atmospheres for storage of undamaged fruit were also good for storage of damaged fruit. Additional studies done in 1993-94 included experiments attempting to mimic TABM damage artificially on fruit while still on the trees. Apples with natural TABM damage were inoculated with *P. expansum* before storage to insure decay potential.

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ORAL SESSION 21 (Abstr. 147-153) Vegetable (Cucurbit): Breeding and Genetics

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GENETIC DIVERSITY, AND INHERITANCE AND LINKAGE OF ISOZYME LOCI IN MELON (*Cucumis melo* L.)

V. V. Meglic*, T. F. Horejsi and J. E. Staub, USDA-ARS and University of Wisconsin, Horticulture Department, 1575 Linden Dr., Madison, WI 53706; and J. D. McCreight USDA-ARS, 1636 E. Alisal, Salinas, CA 93905.

The genetic diversity of 400 U.S. melon germplasm plant introductions was assessed using 35 enzyme systems. Polymorphisms were observed at 24 putative loci (Ac, Acp1, Acp4, Ak2, Ak3, Ak4, Fdp1, Fdp2, Fdp4, Gpi, Idh, Mdh2, Mdh4, Mdh5, Mdhb, Mpi1, Mpi2, Pgd1, Pgd2, Pgm, Pep-gl, Pep-la, Pep-pap, Skdh) representing 17 different enzymes. Sixteen loci demonstrated simple Mendelian inheritance. Multivariate analyses aided in reduction of data using 16 loci and linkage relationships were observed among the plant introductions. Two of 16 loci (Pgd1 and Acp1) segregated independently. Fourteen loci were assigned into three linkage groups (A-C): A Fdp1, Fdp2, Acp4, Skdh; B Mdh2, Mdh4, Mdh5, Mdh6, Pep-gl, Pgm; C Mpi2, Ac, Idh.

GENOTYPE X ENVIRONMENT INTERACTIONS OF MUSKMELON HYBRIDS FOR YIELD AND FRUIT SIZE

David W. Wolff*, Marvin E. Miller, and Carmen Lander, Texas Agricultural Experiment Station, Texas A&M University System, 2415 E. Highway 83, Weslaco, TX 78596

The nature and magnitude of genotype x environment interactions will determine the extent of testing required (locations, years) to accurately evaluate a genotype's performance. Data from yearly T-AES muskmelon variety trials were analyzed to determine the level of variety (V) x year (Y), V x location (L), and V x Y x L interactions for yield and fruit size. Data analyzed were of nine hybrids grown at three commercial farms over two years. Fruits were harvested similar to grower practices, and were sorted into size classes (9 - 30) or culls. V x Y and V x L interactions for marketable yield and total yield were not significant. V x Y x L interaction was significant for marketable yield, but not for total yield. V x Y x L interactions were highly significant for percentage culls and percentage of fruit in each size class. V x L interactions were also significant for percentage of fruit in most size classes. Data indicate that specific location-year combinations differentially affect a genotype's fruit size, most likely due to weather, planting time, and stress factors. Multiple year and location testing of genotypes is therefore critical, particularly for evaluation of fruit size.

DIFFERENTIAL REACTIONS OF MELONS TO ISOLATES OF PAPAYA RINGSPOT VIRUS WATERMELON STRAIN

Patti Fashing-Burdette and James D. McCreight*, U.S. Department of Agriculture, Agricultural Research Service, U.S. Agricultural Research Station, 1636 East Alisal Street Salinas, CA 93905

In 1963, melon (*Cucumis melo* L.) plant introductions (PI) 124112 and PI 180280 were reported variable in response to inoculation with the T-1 or Freitag's isolates of watermelon mosaic virus. Most plants were symptomless, but some had small pinpoint necrotic lesions on cotyledons and leaves. The T-1 and Freitag's isolates of watermelon mosaic were later designated watermelon mosaic virus 1, and more recently renamed papaya ringspot virus watermelon strain (PRSV-W). When inoculated with California or Florida isolates of PRSV-W in 1993, WMR 29 a western U.S. shipping type melon derived from PI 180280 was symptomless (incompatible reaction) and SDS-immunodiffusion assays were negative. In contrast when inoculated with the same PRSV-W isolates, PI 124112 had incompatible reactions characterized by wilting, local lesions, systemic necrotic spots and necrosis and negative SDS-immunodiffusion assays.

THE IDENTIFICATION OF TETRAPLOID REGENERANTS FROM COTYLEDONS OF DIPOLOID WATERMELON AND THEIR USE IN BREEDING TRIPLOID HYBRIDS

Michael E. Compton*, D.J. Gray and G.W. Elmstrom, University of Florida, IFAS, Central Florida Research and Education Center, 5336 University Ave., Leesburg, FL 34748.

Tetraploid individuals were identified among plants regenerated from cotyledons of diploid watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] cultured *in vitro*. Tetraploid and diploid plants were distinguished by counting the number of chloroplast per guard cell pair. The mean number of chloroplasts was 19 and 11 for tetraploid and diploid plants, respectively. Self-fertile tetraploids were obtained from the diploid cultivars Mickylee, Jubilee II and Royal Sweet. 'Dixielee' and 'Minilee' tetraploids failed to set fruit. Progeny obtained from self-fertile tetraploids were crossed with diploid pollinators to produce triploid hybrid seed. All triploid plants produced seedless fruit that was superior or equal to fruit produced by currently available triploid hybrids. This demonstrates that tissue culture can be used to produce high quality tetraploid plants for use in triploid hybrid seed production.

HIGH YIELDS OF SUMMER SQUASH LINES AND HYBRID COMBINATIONS.

Sergio Garza Ortega* and Andres Tacho Amaya, Departamento de Agricultura y Ganaderia, Universidad de Sonora, Ap. Postal 305, Hermosillo, Sonora, 83000 Mexico.

The Gray Zucchini cultivar of summer squash is widely consumed as a fresh market vegetable in Northwest Mexico but is highly susceptible to viral diseases. Gray Zucchini type lines were developed by interspecific hybridization using a local landrace of *Cucurbita moschata*, which has shown high levels of viral resistance, as male parent and susceptible *C. pepo* cv. classic as female. The lines were obtained after 4 backcrossing and 3-5 selfing generations. In 1993 average commercial yield of first generation

hybrids between lines was 28,155 kg/ha followed by line x Gray Zucchini hybrids, lines, commercial hybrids (Classic, Corsair, Onyx, Raven), and open pollinated cultivars (Gray Zucchini, Black Zucchini) with 26,594, 21,062, 18,862 and 10,172 kg/ha respectively. Yield was inversely related to symptoms of viral infection.

GENETIC ANALYSIS OF CUCUMBER QUANTITATIVE TRAITS IN THE PARENTS AND THEIR F₂ DIALLEL ANALYSIS.

Seif H. Gad El-Hak*, Saved. H. Mahmoud. Mohamed A.. Abobakr and Ragab M. Alv. Dept. of Hort., Fac. of Agric., El-Minia Univ.. El-Minia, Egypt.

Five lines of cucumber and their 10 F₂ diallel crosses were statistically and graphically analyzed to evaluate their performance for eight quantitative traits. Additive and non-additive gene effects were involved in the inheritance of all traits. The variances due to GCA and SCA effects were highly significant for all traits, but the GCA effect was much greater than SCA except in the case of plant height. The cucumber "TMG-1" and "Yomaki" genotypes were superior for GCA as well as SCA for early and total yields per plant, respectively. Therefore, they can be involved in hybrid programs improvement for cucumber yield under similar conditions.

GENES FOR INTENSE COLORATION OF ACORN SQUASH

Harry S. Paris, Department of Vegetable Crops, A.R.O., Newe Ya'ar Research Center, P. O. Haifa, Israel.

The fruits of *Cucurbita pepo* cv. Table Queen are light green when young, turn dark green by intermediate age (15-18 days past anthesis) and remain dark green through maturity. Three major genes are known to affect developmental fruit color intensity in *C. pepo*: D, 1-1, and 1-2. Table Queen was crossed with cv. Vegetable Spaghetti and with tester stocks of known genotype in order to determine the genetic basis of its developmental fruit coloration. The results from filial, backcross, and testcross generations suggest that Table Queen carries gene D, which confers dark stem and fruit color from intermediate fruit age through maturity. Table Queen also carries L-2, which confers Light Type 2 (a pattern of grayish green hue) fruit color from intermediate age, but D is epistatic to L-2. The genotype of Table Queen is D/D 1-1/1-1 L-2/L-2. Clear-cut results were not obtained -- regarding the genetic basis of the retention of green color through maturity of Table Queen fruits.

73 ORAL SESSION 22 (Abstr. 154-160) Vegetable (Tomato): Culture and Management

WATER QUANTITY AFFECTS QUALITY OF DRIP-IRRIGATED TOMATO FRUIT

J.K. Brecht*, S.J. Locascio and K.A. Bergsma, Horticultural Sciences Dept., University of Florida, Gainesville, FL 32611-0690

Tomatoes (var. Sunny) were grown using drip irrigation and polyethylene mulch in a three-year study with water applied to plots at 0, 0.25, 0.50, 0.75 and 1.00 times pan evaporation in one application per day. Breaker stage fruit were harvested twice each season at 7 to 10 day intervals and evaluated after storage for 11 days at 20C. Response to water application varied with seasonal rainfall levels. Soluble solids levels decreased with increasing water quantity only in the first (relatively dry) season, while titratable acidity levels decreased with increasing water in all three seasons. Fruit color was not affected by water quantity in the first season but hue angle increased and chroma decreased with increasing water in the second and third seasons. Decay incidence (associated primarily with blossom end rot) was higher in nonirrigated than irrigated treatments and in the second harvests. Internal white tissue, a symptom of irregular ripening, was more common in irrigated treatments and in the wetter second and third seasons.

INFLUENCE OF CONSERVATION TILLAGE ON SOIL TEMPERATURE AND TOMATO YIELD

Ronald W. Garton*, Agriculture Canada, Research Station, Harrow, Ontario N0R 1G0, Canada

Processing tomatoes were planted on a sandy loam soil on raised beds which were prepared in a conventional method with a power bedder (PB), or with conservation tillage (CT). The CT treatments were prepared by using Glyphosate herbicide to burn-off a fall-seeded rye cover crop at either 10cm, 15cm or 30cm height. The center of the bed was tilled with a modified conservation tillage coulters caddy, prior to planting the tomatoes, to loosen the soil but leave the rye residue on the surface. Crop residue cover on the soil surface after planting the tomatoes increased from 9% in the PB treatment, to 63% with CT at 30cm. Increasing crop residue cover resulted in cooler soil temperatures during the day and warmer soil temperatures at night. Transplant survival and early growth was comparable between the tillage systems. Tomato yield was approximately 10% higher in the PB treatment than in the CT treatments. In the conservation tillage treatments, the tomato plants had lower total nitrogen concentrations in the petioles. Nitrogen immobilization by microbes in the decaying cover crop residue may have contributed to the lower petiole N concentrations, and the yield reduction.

INFLUENCE OF MUNICIPAL SOLID WASTE (MSW) COMPOST ON GROWTH, YIELD, AND HEAVY METAL CONTENT OF TOMATO.

M. Ozores-Hampton*, B. Schaffer and H.H. Bryan, University of Florida, IFAS, Tropical Research and Education Center, Homestead FL 33031

The effects of amending soil with municipal solid waste (MSW) on growth, yield and heavy metal content of tomato were tested with different irrigation rates. The following MSW materials were incorporated into oolitic limestone soil: 1) Agrisoil compost (composted trash), 2) Daorganite compost (sewage sludge), 3) Eweson (composted trash and sewage sludge), and 4) no MSW (control). Two rates (high and low) were applied to the soil for each compost. There were no significant effects of irrigation rate on any of the variables tested for tomato in 1991 or 1992. Therefore, the lowest irrigation rate appeared to be adequate for optimum tomato production. Plants grown in Daorganite at the lowest rate of 8 t/ha had greater growth and yield than plants grown in the other MSW materials or the control. Agrisoil and Eweson composts did not increase growth or yield, which may have been due to suboptimal application rates of these materials. There were no differences in the concentration of heavy metals in fruit or leaves among MSW materials or rates. MSW rate generally had no effect on root heavy metal concentration, except for Eweson where the high rate resulted in a higher root zinc concentration than the low rate. There were significant differences in root concentrations of lead, zinc, and copper among MSW materials. Leaf concentrations of all heavy metals tested were within normal ranges for tomato.

SUITABILITY OF A SHREDDED NEWSPAPER, KITCHEN WASTE COMPOST AS A ROOT SUBSTRATE FOR TOMATO SEEDLINGS

Bradford C. Bearce* R.G. Diener, A.R. Collins, and G. Bissonette, West Virginia University, Division of Plant and Soil Sciences, P.O. Box 6108, Morgantown, WV 26506-6108

A small, continuous flow compost reactor was employed to produce a compost from a shredded newspaper/kitchen waste mixture. Transit time through the reactor was 4 weeks and the compost was then stockpiled for 5, 7, 8 or 9 weeks prior to evaluation. Cress seed germination was not reduced in graded aqueous compost extracts, however, seedling radicle length was significantly reduced in the nondiluted extract. Elemental analysis of the compost showed PO_4 and K to be about 20 and 2 times recommended levels and No 5 times the maximum level at 577 mg. liter⁻¹. Electrical conductivity of the compost was 5 dS.m⁻¹ and pH range was 6.2-7.3. Composts were leached with water to E.C.'s of 1-1.5 dS.m⁻¹ before planting tomato seedlings. Dry weights of tomato seedlings grown 5 weeks in the composts were equal to those in a peat vermiculite control, except that dry weights of seedlings in the compost stockpiled for 5 weeks were less than those of control plants. Some residual inhibition of growth may have remained in the compost for at least 5 weeks after the production date but by the 7th week, no growth inhibition was apparent.

Effects of supplemental lighting and cluster pruning on yield, photosynthesis, and sugar accumulation of greenhouse tomato plants

Mohammed Dafiri and André Gosselin*. Département de phytologie, Centre de recherche en horticulture, Faculté des sciences de l'agriculture et de l'alimentation, Université Laval, Québec, Canada G1K 7P4

Tomato plants were submitted to three photosynthetic photon fluxes (PPF) of 50, 100, and 150 $\mu\text{mol. m}^{-2}\text{s}^{-1}$ and cluster-pruned according to different scenarios. The highest PPF combined with severe cluster pruning produced the highest yield and the best fruit quality. The highest PPF increased growth, photosynthesis and leaf sugar content. Severe cluster pruning increased the average fruit weight, leaf sucrose and glucose content, but reduced photosynthesis. Data will be discussed in relation to crop management and efficiency.

EVALUATION OF A NUTRIENT/MOISTURE GRADIENT FOR PRODUCTION OF CONTAINERIZED TOMATOES

C. M. Geraldson*, Univ. of Florida, Gulf Coast Research and Education Center, 5007 60th St. East, Bradenton, FL 34203.

The gradient concept, which has been used to provide nutritional stability in a field orientated full-bed mulch production system, is being evaluated as a component in a containerized concept. Conceptionally, the nutrient/water Input must be synchronized with removal. A built-in water table and a time-clock regulated microirrigation procedure were evaluated as water sources. A reservoir of soluble N-K banded at the media surface was used to maintain and evaluate the nutritional gradient. Container design, choice of media, plant populations and even dual containers are being evaluated and selected to enhance the functional efficiency of the concept. Yields of 6.8 to 13.6 kgs of marketable, above average quality tomatoes per plant have verified the feasibility of the concept. The containerized gradient concept using minimal water with minimal pollution and using the gradient approach to allow a maximum productivity with minimal management, has the potential to become a globally sustainable production system.

TOMATO PRODUCTION IN KUWAIT

Mahdi S. Abdal* and Charles Basham, Kuwait Institute for Scientific Research, P.O. Box 24885, Safat 13109, Kuwait.

Tomatoes are the leading vegetable crop in Kuwait and are produced in both open field agriculture (OFA) and protected environment agriculture (PEA). Prior to the invasion by Iraq there were 1018 ha of tomatoes in OFA and 76 ha in PEA. We project that nearly 90% of the pre-invasion PEA area and more than 50% of the OFA area will be restored to production in the 1994 season.

Most of the PEA structures currently in production are simple structures of bent pipe frames with plastic film covers. Some multi-span, rigid-cover structures have been restored. Fan and pad cooling systems are used although many of the structures are uncooled and produce only a winter crop.

PEA production uses desalinated sea water (DW) for irrigation and a mixture of DW and brackish water (BW) for cooling. OFA uses a mixture of DW and BW for irrigation, usually applied with drip systems.

Pest problems include whitefly, spider mite, aphid, root knot nematode and a number of diseases including tomato yellow leaf curl.

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CALCINED CLAY AND ALUMINA AMENDMENTS INCREASE PO_4 AND K RETENTION OF SOILLESS CONTAINER SUBSTRATES

Kimberly A. Williams* and Paul V. Nelson, Dept of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Soilless substrates have little capacity to sorb PO_4 . One way to reduce PO_4 leaching during production is to increase the substrate retention of PO_4 . Adsorption isotherms were created at 25 C for alumina (aluminum oxide); the 2:1 calcined clays arcillite (montmorillonite plus illite) and attapulgite; and a

medium of 70 peat: 30 perlite using solutions of KH_2PO_4 at rates of P ranging from 0 to 20000 $\mu\text{g}\cdot\text{ml}^{-1}$. Material sorbed at the rate resulting in maximum P adsorption was then desorbed 22 times. Sorbing concentrations necessary to establish an equilibrium P concentration of 10 $\mu\text{g}\cdot\text{ml}^{-1}$ in the substrate solution were estimated from these curves. Materials were charged with P at these estimated rates and evaluated in a greenhouse study in which each material was tested at 10 and 30% by volume of a 70 peat: 30 perlite substrate used to produce *Dendranthema x grandiflorum* 'Sunny Mandalay'. Phosphate, K, and pH were determined on unaltered soil solutions biweekly throughout the cropping cycle and foliar analyses were determined on tissue collected at mid- and end-crop. Isotherm and greenhouse data indicated that alumina, arcillite, and attapulgite effectively retained and slowly released K as well as PO_4 over time. Alumina was most effective at retaining P, sorbing 16800 $\mu\text{g}/\text{cc}$ compared to 3100 and 7800 μg P sorbed/cc for arcillite and attapulgite, respectively, when sorbed at P concentrations resulting in an equilibrium concentration of approximately 10 μg P/ml.

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GROWTH AND FLOWERING RESPONSES OF 'DARK RED HEGG' POINSETTIAS IN COAL ASH-AMENDED ROOT MEDIA TO 3 NUTRIENT SOLUTIONS IN A CLOSED-LOOP NUTRICULTURE SYSTEM

Kristen B. Engstrom*, Susan G. Myers, and Bradford C. Bearce, West Virginia University, Division of Plant and Soil Sciences, P.O. Box 6108, Morgantown, WV 26506-6106

Rooted cuttings of 'Dark Red Hegg' poinsettia were potted in root media containing 0, 50, or 100 percent by volume of coal bottom ash in peat:vermiculite (50:50, v/v), one cutting per 1 liter pot. The plants were placed in a closed loop nutriculture system and irrigated with 200 mg N/liter of (N-P-K) 20-8-8-17.8, 15-2-2-22.25, or 20-4-8-21.6 (commercial Hydrosol + $\text{Ca}(\text{NO}_3)_2$), each with soluble trace elements. Fertilizer solutions were maintained at pH=6.0-6.5 and E.C.=1.6-2.5 dS/m³. Media pH and E.C. tended to increase with amount of ash in the media. The 20-8-8-17.8 fertilizer reduced pH values 0.6-0.8 in all media. Plants were of equal height in all media. Average bract cluster diameters of plants in 100 percent coal ash were reduced compared to those in 0 and 50 percent coal ash by the 15-2-2-22.25 fertilizer, but not by the other two fertilizers. Plant top dry weights in 100 percent ash were reduced below those in 0 and 50 percent ash by the 20-8-8-17.8 and the 15-2-2-22.25 fertilizers.

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THE EFFECTS OF HYDROPHILIC GELS ON PETUNIA GROWTH AND DEVELOPMENT IN A COMMERCIAL GREENHOUSE

Karen L. Panter*, Colorado State University Cooperative Extension, 9755 Henderson Road, Brighton, CO 80601

A study was undertaken between June 30 and September 15, 1993 to determine the effects of five different hydrophilic gels on petunia 'Supercascade Red' dry weights, stem lengths, and bud counts. Data were compiled on growing medium and plant tissue analyses as well as days between waterings of gel-amended versus control media. A completely randomized design was utilized with six treatments (five gels and control), 15 pots per treatment, five plants per ten-inch hanging basket. Statistical analyses showed no significant differences either within or among treatments for stem lengths or bud counts, or among treatments for plant dry weights. Two cases of significant differences among pots within treatments did occur. Plant tissue analyses run before and after the study showed consistent increases in N, P, Ca, Mg, S, Zn, and B; decreases in Fe, Cu, and Na; and mixed changes in K and Mn over the 11-week study. Growing medium analyses run before and after the study showed consistent increases in Fe; decreases in EC, % organic matter, $\text{NH}_4\text{-N}$, K, Mg, SO_4 , S, Mn, and Cu; and mixed changes in pH, $\text{NO}_3\text{-N}$, P, Ca, and Zn. There were no significant differences in either the number of waterings or the days between waterings among the six treatments.

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THE POTENTIAL OF COIR (COCONUT MESOCARP PITH) AS A PEAT SUBSTITUTE IN CONTAINER MEDIA.

Alan W. Meerow, University of Florida-IFAS, Research & Education Center, Fort Lauderdale, FL 33314.

Coir is the name given to the fibrous material that constitutes the thick mesocarp of the coconut fruit (*Cocos nucifera* L.). The long fibers of coir are extracted from the coconut husk and utilized in the manufacture of various products. The short fibers and dust ("pith") left behind have accumulated as a waste product. Coir pith is light to dark brown in color and consists primarily of particles in the size range 0.2-2.0 mm (75-90%). In composition, it is 65-70% lignin and 20-30% cellulose. To date, few replicated tests have assessed the performance of coir pith as a plant growth medium. From April, 1993 to April, 1994, four ornamental crops (pentas, ixora, anthurium and majesty palm) were grown in container media that differed only in the peat fraction (40%), either sphagnum, Florida (sedge) peat, or coir pith. On the basis of plant

growth parameters, coir pith was superior to sedge peat as a medium component (though only marginally for the anthurium) and at least equal to sphagnum peat. In addition to physical qualities equal to or better than sphagnum peat, coir decomposes more slowly than either sedge or sphagnum peat, withstands compression better and is easier to wet than peat. There are also no ecological drawbacks to the use of coir -- a waste product -- relative to the harvest of peat from wetland ecosystems.

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VESICULAR-ARBUSCULAR MYCORRHIZAE DECREASE DAYS TO FLOWERING AND INCREASE INFLORESCENCE NUMBER OF GERANIUM 'SPRINTER SCARLET' GROWN IN THREE SOILLESS MEDIA.

Peter M. Shaw* Horticulture Department, Spokane Community College, N.1810 Greene St. MS2080, Spokane, WA 99207, Rita Hummel, Department of Horticulture and Landscape Architecture, Extension and Research Center, Puyallup, WA

The effects of vesicular-arbuscular mycorrhizae (VAM) on the growth and flowering of Geranium 'Sprinter Scarlet' in three greenhouse soilless media were investigated. All media proved to be well suited for geranium growth and VAM had no significant effect on most vegetative parameters. However, VAM significantly reduced the number of days to flowering of plants grown in Mycori-Mix and Sunshine Aggregate #4 by 6.4 and 6.6 days respectively. Plants grown in Mycori-Mix with VAM flowered 99.4 days after sowing, significantly sooner than those grown in the other media with VAM. Mycorrhizal plants in Mycori-Mix and Metro Mix had a greater number of lateral branches >5 cm in length than non-mycorrhizal in the same media. Regardless of VAM treatment, plants grown in Mycori-Mix had a greater number of visible inflorescences at harvest than the other two media.

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NITROGEN UPTAKE BY ROSES IS ENHANCED BY INTERMITTENT N DEPRIVATION.

Raul I. Cabrera*, Richard Y. Evans and J.L. Paul, Dept. of Environmental Horticulture, University of California, Davis, CA 95616. *Current address: Dept. of Plant Science; Rutgers University, New Brunswick, NJ 08903.

N deprivation is known to increase the rate of N uptake by graminaceous plants, but such response has not been reported for mature woody plants. A recirculating nutrient solution system was utilized to study the effect of intermittent N-deprivation on N uptake by mature 'Royalty' rose plants. Plants received a nutrient solution lacking N for 4, 8 or 16 days, after which one containing N was supplied for 4 days. N-deprivation resulted in a 2-3 fold increase in N uptake rate compared to control plants supplied continuously with N (e.g., 143 vs 62 mg N plant⁻¹ day⁻¹). The magnitude of this deprivation-enhanced N uptake was not affected by either the duration of N-deprivation or the plant developmental stage.

A characteristic diurnal pattern of N uptake was observed in both N-starved and control plants. Uptake oscillated between minimum rates in the morning and maximum rates in the evening, the latter occurring 4-6 hr after the maximum transpiration rates.

The ability to increase the rate of N uptake in roses by depriving them of N for several days may be of practical importance for increasing N fertilizer use efficiency and decreasing N losses to leaching.

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COMPARISONS OF GREENHOUSE BENCHING / IRRIGATION SYSTEMS FOR WATER USE, FERTILIZER USE, AND CROP QUALITY WITH POINSETTIAS AND GERANIUMS.

Dawn M. Alleman* and Thomas C. Weiler, Dept. of Floriculture and Ornamental Horticulture Cornell University, 20 Plant Science Building, Ithaca, NY 14853

Four experiments were conducted over 2 years focusing on water and fertilizer delivery methods with emphasis on minimal resource use. Poinsettia 'Freedom', 'Celebrate2', 'Peppermint Pink', 'Angelika White', 'Lilo' and 'Angelika Marble' and geranium 'Kim', 'Aurora', 'Ritz', and 'Melody' cuttings were grown in 6 inch pots with peat-lite mix and were harvested at marketable size. Nitrogen efficiency was compared by replicating each irrigation treatment with soluble fertilizer (SF) and controlled release fertilizer (CRF). Crops grown with SF were started at 225ppm N for several weeks, then finished at 125ppm N after monitored EC had dropped below 1000 μS . CRF treatments were potted up with 1.6 total grams of N available to the plant and irrigated throughout production with tap water. Irrigation treatments included: drip tube leaching, drip tube, ebb & flow, trough, trough lined with capillary mat, trough lined with plastic-covered capillary mat, flats of capillary mat, flats with plastic-covered capillary mat. Daily irrigation volumes were recorded. Weekly data collection included EC, pH, nitrate nitrogen, and ammonium nitrogen. Harvest data included plant dry weight, and total nutrient analyses of plants and substrate. Water efficiency was significantly improved in recirculating systems and with capillary mat systems. No significance was noticed in dry weight or final nutrient analyses across treatments. Significance existed in water quality throughout crop production.

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EFFECT OF PLANTING DATE AND ROW COVER UTILIZATION ON YIELD OF 'CHANDLER' IN A HIGH-DENSITY ANNUAL SYSTEM
Joseph A. Fiola*, Peter Probasco, and Stephen Garrison, Rutgers R&D Center, Upper Deerfield, NJ, 08302

An RCB (4 replicates - 4 m plots) planting of 'Chandler' was established to test the effects of planting date and floating row covers (FRC) in a high density strawberry planting system under NJ conditions. Transplant "plugs" from runner tips were planted on a double row (0.5 m x 0.3 m) on a raised plastic mulch bed (1.5 m centers), with trickle irrigation. Treatments included: plant 9/18/91 w/FRC on 10/7/92; plant 9/18/91 w/FRC on 12/2/92; plant 9/18/91 w/noFRC; plant 10/7/91 w/noFRC; plant 9/14/92 w/FRC on 10/7/92; plant 9/14/92 w/noFRC. In 1992, 'Chandler' yield increased with earlier planting date and earlier FRC application (range: 8,600 to 13,400 kg/ha). There were no significant differences in cull or fruit weight. In 1993, there were no significant differences in 2nd year yield for 1991 treatments (range: 19,198 to 20,531 kg/ha). However, the 1992 treatments again showed the benefit of FRC (range: 13,437 to 20,531 kg/ha) for improved first year production. One year old plots had significantly larger average fruit weight than two year plots (range: 10.3 to 13.7 g). Early planting date with early applied FRC was the best treatment, combining high yield and good fruit weight.

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NURSERY SOIL FUMIGATION TREATMENT, STOLON PRODUCTION, AND SUBSEQUENT GROWTH OF STRAWBERRY PLANTS IN CALIFORNIA
Kirk D. Larson, University of California South Coast REC, Irvine, CA 92718

Replant soil fumigation with mixtures of methyl bromide (MeBr) and chloropicrin (trichloronitromethane) is a standard practice for pest and disease control in fruit crop nurseries in California. The proposed phase-out of MeBr by the year 2001 requires that alternative soil sterilants be studied for nursery use. Therefore, on 5 April, 1993, three preplant soil treatments were applied to new strawberry ground: 1) MeBr/chloropicrin (67:33) at 392 kg/ha; 2) chloropicrin, a possible MeBr substitute, at 140 kg/ha; and 3) nonfumigation. The experimental design was a RCB: there were two plots (each 10' x 15') for each of two cultivars ('Chandler' and 'Selva') for the 3 soil treatments in each of 3 blocks. Mother plants were planted 26 April, and plots were machine-harvested in October, 1993. All plants from each plot were uniformly graded, after which mean stolon yield per mother plant, mean crown diameters, and crown and root dry wts were determined. Cultivar effects and cultivar x treatment interactions were not observed, so data for the two cultivars were pooled. Stolon production per mother plant was greatest for trt 1 (18.56 stolons), intermediate for trt 2 (15.75 stolons), and least for trt 3 (7.89 stolons). For trt 3, crown diameters, and crown and root dry wts were reduced relative to those of trts 1 or 2. Stolons from all trts were planted in a fruit production field on 13 October, 1993. After two months, canopy diameters were greatest for plants from trt 1 (27.1 cm), intermediate for plants from trt 2 (26.2 cm) and least for plants from trt 3 (24.9 cm). The results indicate that, compared to standard soil fumigation with MeBr/chloropicrin, small, but significant, reductions in runner production and plant vigor can be expected following nursery soil fumigation with intermediate rates of chloropicrin.

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DRIP IRRIGATION OF PLASTIC-MULCHED STRAWBERRY USING CARBONATED WATER-A GREENHOUSE STUDY

Margaret L. Shore*, Harrison G. Hughes, Frank D. Moore, Department of Horticulture and Danny H. Smith, Department of Agronomy, Colorado State University, Fort Collins, CO 80523

Carbonated water (CW) application has enhanced yields of tomato. However, little is known about the mechanism of this response. Our objectives were to determine if strawberry would respond to CW application and the effect of soil pH modification on the expression of a yield response. Two different soils were used; a calcareous soil (5% CaCO₃, pH 7.9), with a Zn content 0.8 ppm and a non-calcareous soil (< 1% CaCO₃, pH 6.5) with a Zn content 8.8 ppm. The carbonated water temporarily lowered the pH of the calcareous soil to 6.7 and the non-calcareous soil to 5.9, at both extremes of the optimal range (6.0-6.7) for strawberry. Application of carbonated water increased production of marketable fruit as compared to the tap water control on both soils, and the magnitude of the response to CW was similar for both soils. Soil and water treatment effects on leaf tissue Zn levels will also be discussed.

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GROUND COVER AND SUPPLEMENTARY IRRIGATION INFLUENCES THE ESTABLISHMENT OF PRIMOCANE-FRUITING RED RASPBERRIES.

David C. Percival*, John T.A. Proctor and J. Alan Sullivan, Department of Horticultural Science, University of Guelph, Guelph, Ontario, Canada. N1G 2W1.

A study examining the influence of trickle irrigation (TI), IRT-76 plastic film (PF) and straw mulch (SM) on the establishment of *Rubus idaeus* L. cv. 'Heritage' micro-propagated raspberries was initiated at Cambridge, Ontario in 1993. Environmental, nutritional, vegetative and reproductive data were collected. Soil temperature and soil water status were greatly affected by TI, PF and SM. TI lowered soil NO₃-N and increased soil NH₄-N and Mg. PF increased soil NO₃-N and NH₄-N. Foliar N decreased by 10% with TI and increased by 8% with PF. Foliar P and Ca increased by 45 and 6% respectively, with TI. Node number was not influenced by TI, PF or SM. PF however, increased cane height, cane diameter, dry weight and leaf area by 14, 17, 77 and 11% respectively, and TI increased cane diameter by 13%. Although TI increased the number of fruiting laterals by 63 %, there was no effect of TI, PF or SM on harvested berry number or weight.

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STRAW MULCH INCREASES YIELD OF THORNLESS BLACKBERRY CULTIVARS

Richard C. Funt*, Henry M. Bartholomew, Mark C. Schmittgen and John C. Golden, Department of Horticulture, The Ohio State University, Columbus, OH 43210-1096

Annual yields of thornless blackberries may be inconsistent due to low winter or early spring temperatures. Under ideal conditions thornless blackberries can produce two or three times more berries per acre and ripen over a longer period of time than the erect, thorny type.

Yields of several thornless blackberry cultivars were improved by using straw mulch. In experiment one standard cultivars were compared to numbered clones. In experiment two Chester, Black Satin, Dirksen and C-65 were compared. Over a six year period, straw increased yields from 1670 to 8300 pounds per acre. Straw mulch appeared to be effective during years where low temperatures did not affect bearing surface.

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CRANBERRY PLANTS COMPENSATE FOR UPRIGHT TIP DESTRUCTION BY CRANBERRY TIPWORM

Carolyn DeMoranville* and Anne Averill, University of Massachusetts Cranberry Experiment Station, P. O. Box 569, E. Wareham, MA 02538

Cranberry tipworm (*Dasyneura vaccinii* Smith) lays its eggs in the upright tips of cranberry (*Vaccinium macrocarpon* Ait.) plants. Feeding damage by newly hatched maggots leads to characteristic cupping of leaves in the upright tip. This damage is readily apparent to growers and has led to concern that damaged tips would not form terminal flower buds for the following season. Insecticide sprays and cultural practices intended to control this insect are generally ineffective. While studying the incidence of return bloom in cranberry uprights (Strik, B. C., et al. 1991. HortScience 26:1366-1367) heavy cranberry tipworm injury with little apparent effect on yield was noted. We initiated a three year study to examine the potential for cranberry plants to recover from tipworm injury and found that cranberry plants recover completely (no effect on flower bud production) from tipworm injury as long as the injury occurs before mid-August. Only 25% recovery from late-season infestations was found. However, such infestations seldom affected more than 5% of the upright tips. Based on our data, we calculated a maximum 6% loss of flower buds to cranberry tipworm in a year of high late-season infestations.

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USING FERAL AND COMMERCIAL BUMBLE BEES FOR POLLINATION OF CRANBERRIES AND PEARS

Kim Patten*, Rod Macfarlane and Dan Mayer, Washington State University - Long Beach, Rt 1 Box 570, Long Beach WA 98631

The pollination of cranberries and pears by honey bees is often inadequate. The pollination efficacy of feral (*Bombus* spp.) and/or commercial bumble bees was evaluated for these crops. Preliminary evaluation of commercial *B. vosnesenskii* and *B. occidentalis* hives indicated poor forage activity on pears, but good activity on cranberries. Hive stocking densities of *B. occidentalis* on cranberries

required to match feral *Bombus* populations was 8-10 hive/ha. Hives required 1-2 weeks in the field prior to full bloom to achieve suitable forage density during bloom. Parasitism of commercial hives by wax moth and bumble bee brood fly was common. Commercial colonies did not appear to be cost effective at this time. Only short-tongued feral *Bombus* species foraged on cranberries. Acceptance of artificial domiciles by these species was poor. Enhancing feral populations required provision of supplemental food sources and improved nesting habitat. Management of alternative food resources for feral bumble bees will be discussed.

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GENETIC TRANSFORMATION OF COFFEE (*COFFEA ARABICA* L.) BY *AGROBACTERIUM* SPP.
A. Virginia Freire*, David A. Lightfoot, and John E. Preece. Department of Plant and Soil Science, Southern Illinois University, Carbondale, IL 62901-4415.

Efficient genetic transformation could enhance coffee breeding, which is limited by its long generation time and narrow genetic base. Three explant types of three coffee cultivars were inoculated with 14 strains of *Agrobacterium* spp. Callus and hairy roots were produced with 13 of the 14 strains tested. With *A. tumefaciens*, nopaline strains were more effective than octopine strains. Cucumopine and mannopine strains of *A. rhizogenes* were both effective in inducing hairy roots and callus. PCR amplification of a 0.72 Kb fragment of T-DNA encoding a portion of the *ipt* gene was achieved with DNA from *A. tumefaciens* strain A208 and with putatively transformed tissue inoculated with A208. No amplification was observed with *virB* in putatively transformed tissue which indicates it was not contaminated with *Agrobacterium*. We conclude that coffee can be genetically transformed by some *Agrobacterium* strains.

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DYNAMIC INTERACTION OF INSERTED GENE PRODUCTS AND NATURALLY OCCURRING COMPOUNDS IN CRANBERRY.

Rodney Serres* and Brent McCown, Department of Horticulture, 1575 Linden Drive, University of Wisconsin-Madison, Madison, WI 53706.

The gene encoding β -glucuronidase, *GUS*, has been inserted into cranberry and is expressed in various tissues. Detectable expression of the *GUS* gene is enhanced up to 15x when the phenol-adsorbing compound, polyvinylpyrrolidone, is included in the extraction buffer of the fluorometric MUG assay, indicating that an endogenous, probably phenolic, compound is inactivating the foreign enzyme. Extracts from in vitro-grown cranberry leaves reduce the activity of purified β -glucuronidase in fluorometric assays. This is in contrast to extracts from other plants which have no effect on the enzyme. Detectable expression of the *GUS* gene for an individual transclone varies with the age of the tissue and the environment in which the plant is grown. The *BT* gene, which encodes for the *Bacillus thuringiensis* δ -endotoxin, was also inserted into cranberry with the purpose of incorporating lepidopteran insect resistance. Bioassays using an important insect pest on cranberry show generally inconsistent feeding patterns on transgenic plants. These results may be due to the interaction of the endogenous compounds and the *B.t.* δ -endotoxin.

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TRANSGENIC PEACH PLANTS CONTAINING A CYTOKININ BIOSYNTHESIS GENE DISPLAY ALTERED GROWTH IN VITRO AND UNDER GREENHOUSE CONDITIONS

F.A. Hammerschlag* and A.C. Smigocki, USDA/ARS, PSI, Plant Molecular Biology Laboratory, Beltsville, MD 20705
Transgenic plants containing introduced phytohormone genes have been shown to display altered growth and morphogenetic potential. Peach plants transformed with the *ipt* gene from *Agrobacterium tumefaciens* strain *ims 328::Tn5* and containing elevated levels of cytokinins were screened in vitro for compact growth habit on four different levels of 6-benzyladenine (BA). After nine weeks in vitro, the average number of axillary shoots per plant for two of the

transformants, 99-1 and 40-1, ranged from 1.5 to 6.6 times that for the controls on 0-30 μ M of BA, whereas average fresh weight ranged from 1.1 to 3.6 times that for the controls. One of the transformants, 94-1, produced a greater number of axillary shoots only on 30 μ M BA. Rooted plants derived through micropropagation from the original transformants were monitored for 30 months under greenhouse conditions. The average height of transformants 94-1 and 99-1 after six months in the greenhouse was 88 and 77% of controls, respectively and after 30 months was 90 and 75% of controls, respectively. In comparison to controls, transformants exhibited a greater number of branches per meter per plant after six weeks, but a lesser number after 30 months. These results suggest that the introduction of a cytokinin gene may be a useful approach to obtaining peach trees with a compact growth habit.

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RESISTANCE TO CODLING MOTH: EXPRESSION OF SYNTHETIC CRYIA(C) GENES IN TRANSGENIC WALNUT EMBRYOS
Abhaya M.Dandekar*, Gale H McGranahan, Patrick V. Vail', Sandra L. Uratsu, Charles Leslie, and J. Steven Tebbets', Department of Pomology, University of California, Davis CA 95616 USA and 'Horticulture Crops Research Labs., USDA/ARS 2021 South Peach Ave, Fresno CA 93727

Insecticidal crystal protein fragments (ICPFs) of *Bacillus thuringiensis* (Bt) encoded by *cryIA(c)* gene were shown in diet incorporation studies to be lethal to codling moth (CM; *Cydia pomonella*) the key insect pest for walnut. However transformed walnut tissues expressing *cryIA(c)* with Bt codon usage patterns and native DNA sequence revealed very low levels of expression in *planta*. To correct this problem synthetic versions of one of these genes, *cryIA(c)* was used to transform walnut tissue. A total of 61 individual transgenic embryo lines were obtained. 34% of these lines (21/61) were high expressors ("class A") demonstrating 80 to 100% mortality of first instar CM larvae and displaying no further larval development. Twelve clones (20%) were designated "class B" and these showed a marked retardation of larval development and a mortality between 40 to 79%. Embryos from the remaining 28 lines designated "class C" (46%), although transformed, were indistinguishable from the control (untransformed embryos) and showed a mortality of 0 to 39%.

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IMPROVED IRON UTILIZATION OF FRUIT TREES THROUGH BIOTECHNOLOGY

Andrew I. Samuelsen, Sumontip Bunnag, Ruth C. Martin, David W.S. Mok, and Machteld C. Mok, Dept. of Horticulture, Oregon State University, Corvallis, OR 97331-7304

Two approaches are used to improve iron utilization of fruit trees under iron-limiting conditions: 1) selection of somaclonal variants; and 2) cloning and incorporation of genes encoding Fe(III) reductases. Two somaclonal variants of quince with tolerance to low iron availability have been selected from 2000+ shoots regenerated from leaf discs. In greenhouse tests, under iron stress conditions, the variant clones continued to show improved iron utilization, having significantly higher chlorophyll concentrations in the new leaves when compared to the quince control. Cloning of Fe(III) reductase genes is based on mutant rescue utilizing a yeast mutant deficient in Fe(III) reduction (Dancis et al., PNAS 89:3869, 1992). A shuttle vector is used to incorporate a tomato root cDNA library into the yeast mutant. Complementing cDNAs, restoring growth to wild-type levels, are selected for further analyses. Cloning of genes involved in iron utilization will eventually lead to transgenic plants with improved iron efficiency.

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GENETIC TRANSFORMATION OF RED RASPBERRY (*RUBUS IDAEUS* L.) WITH A GENE TO CONTROL ETHYLENE BIOSYNTHESIS.

Helena Mathews*, C. Cohen, W. Wagoner, J. Kellogg, V. Dewey and R. Bestwick AgriTope Inc. 8505 SW Creekside Place, Beaverton, Oregon 97005

We have developed efficient plant regeneration and transformation systems for red raspberry (*Rubus idaeus* L.). We have successfully introduced a gene for controlling biosynthesis of ethylene into raspberry for the first time. Leaf and petiole segments were co-cultivated with disarmed *Agrobacterium* strains EHA 101 or 105 containing plasmids pAG5420, pAG 1452 or pAG1552. The plasmids encoded gene sequences for S-adenosylmethionine hydrolase (SAMase) driven by the fruit specific or wound and fruit specific tomato SE8 or E4 promoters. SAMase catalyzes the conversion of S-adenosylmethionine (SAM) to methylthioadenosine (MTA) and homoserine which can reenter the methionine recycling pathway. SAM is therefore not available for the synthesis of 1-aminocyclopropane carboxylic acid (ACC), the metabolic precursor for ethylene biosynthesis. Initial shoot regenerants were mostly chimeras containing transformed and non-transformed cells. Solid clones of pure transgenics were developed by repeated culture of leaf, petiole and nodal explants of primary regenerants on higher stringency selection medium. Transformants were screened on medium with kanamycin, geneticin or hygromycin depending on the selection marker gene NPTII or hpt. Genomic integration of transgenes were confirmed by Southern hybridization. Transgenic plants of cultivars Canby, Meeker and Chilliwack have been transplanted to the greenhouse for fruit set and further evaluation of transgenic traits.

AN ULTRACELLULAR LOOK AT LIGHT-TREATED IPT-TRANSGENIC TOBACCO

Sandra L. Barbour* and Dennis R. Decoteau, Horticulture Department, Clemson University, Clemson, SC 29634.

Similarities exist between the effects of phytochrome and cytokinins on plant growth and development (e.g., chloroplast development, amaranthin synthesis, seed germination, photomorphogenesis). It is unclear, however, if and how these two systems interact.

To determine the effects of phytochrome activity on cytokinin synthesis and ultracellular plant development, we utilized tobacco transformed with the *Agrobacterium tumefaciens isopentenyl transferase (ipt)* gene. This gene encodes for isopentenyl transferase (iptase) which is an enzyme active in cytokinin biosynthesis.

Ipt-transgenic tobacco cultures were treated with end-of-day red or far-red light for 15 minutes. After 15-30 days of treatment, the plant tissue was harvested and *ipt* expression was verified by SDS-PAGE and western blot analysis. Polyclonal antibodies specific to iptase were used as a primary antibody. Colloidal gold conjugated to goat anti-rabbit antiserum served as an electron dense, secondary antibody and a probe to light-influenced iptase synthesis and distribution within the cell.

A Hitachi 600AB transmission electron microscope was used to determine the influence of phytochrome/light treatments on the ultrastructure of ipt-transgenic cells.

COLOR MACHINE VISION ANALYSIS OF IRREGULARLY PIGMENTED CELL SUSPENSION CULTURES

M.A.L. Smith*, J. Reid, A. Hansen, Z. Li and D.L. Madhavi. Depts. of Horticulture and Agricultural Engineering, University of Illinois, Urbana, Illinois 61801

Industrial-scale cultivation of plant cells for valuable product recovery (e.g. natural pigments, pharmaceutical compounds) can only be considered commercially-feasible when a fully-automated, predictable bioprocess is achieved. Automation of cell selection, quantification, and sorting procedures, and pinpointing of optimal microenvironmental regimes can be approached via machine vision. Macroscopic staging of *Ajuga reptans* callus masses (ranging between 2-6 g FW) permitted simultaneous rapid capture of top and side views. Area data used in a linear regression model yielded a reliable, non-destructive estimate of fresh mass. Suspension culture images from the same cell line were microscopically imaged at 4x (with an inverted microscope). Using color machine vision, the HSI (hue-saturation-intensity) coordinates were used to successfully separate pigmented cells and aggregates from non-pigmented cells, aggregates, and background debris. Time-course sampling of a routine suspension culture consistently allowed pigmented cells to be detected, and intensity could be correlated with the degree of pigmentation as verified using spectrophotometer analysis of parallel samples.

84 ORAL SESSION 26 (Abstr. 183-191) Tree Fruits: Thinning/Bloom Delay

ENDOTHALL, A BLOSSOM-THINNING AGENT FOR APPLES

Max W. Williams*, USDA, Agricultural Research Service, Tree Fruit Research Lab., 1104 N. Western Ave., Wenatchee, WA 98801; Sally A. Bound, Newtown Research Lab., Dept. Primary Industries, Hobart, Tasmania; and Jack Hughes and Stuart Tustin, Hort & Food Research Institute, Havelock North, New Zealand.

Endothall [7, oxybicyclo (2,2,2) heptane-2,3 dicarboxylic acid] is an aquatic herbicide which has potential for use as a blossom thinning agent for apples. Trials conducted in Washington State, New Zealand and Australia on several apple cultivars indicate Endothall is a safe, consistent blossom thinner. Cultivars treated were 'Golden Delicious', 'Delicious', and 'Gala'. Single and repeat applications were used in the New Zealand tests. With multiple applications of Endothall, no fruit marking occurred on any of the test cultivars. In temperate fruit zones with extended apple bloom periods, multiple applications of a low rate of Endothall may be beneficial for reducing fruit set and biennial bearing.

Timing of Benzyladenine Application as a Chemical Thinner of 'Empire' Apple.

V.E. Emonger* and D.P. Murr, Horticultural Science Department, University of Guelph, Guelph, Ontario, N1G 2W1, Canada.

Benzyladenine (100 or 200 mg.litre⁻¹) was applied to mature Empire/M.26 apple trees as dilute sprays 2, 4, 9, 11, 13, 15, 17, 20, 25, 27, 29 or 31 days after full bloom (DAFB). The most effective time of thinning was 25-29 DAFB (king fruit diameter 8.94-13.91 mm), and the thinning response to BA concentration was linear. Benzyladenine (BA) did not reduce fruit set when king fruit diameter was less than 5.35 mm, but BA significantly increased fruit weight, diameter (D), length (L) and L:D ratio compared to unsprayed controls and later BA treatments. BA-treated fruitlets had higher ethylene production, 24 hours and 7 days after spraying compared to untreated controls. We suggest that the response of apple fruitlets to BA applied as a thinner is mediated by ethylene. High fruit quality was obtained when BA was applied at 17-31 DAFB. Timing of BA sprays had no effect on seed number, though BA significantly increased seed number, fruit size, weight and L:D ratio. These results suggest that BA has the potential to substitute for the use of carbaryl as a thinner of apples in Ontario orchards.

BIOASSAYS TO DETERMINE OF APPLE THINNING RESPONSE FROM APPLICATIONS OF NAA

J. A. FLORE*, M. VENTURA, D. NERI, AND M. SAKIN, Department of Horticulture, Michigan State University, East Lansing MI 48824-1325.

Auxin induction of ethylene, and fruit growth rates were investigated as early indicators of NAA thinning response for Golden Delicious, Red Delicious, McIntosh, Empire, and Tydemans Red over a four period. Abscission at the end of the drop period was correlated with ethylene evolution from leaves 24-48 hours after NAA application and with changes in fruit growth at 2-3 day intervals through 10-14 days after application. Variation in ethylene evolution and fruit growth were also associated with environmental conditions prior to and at the time of NAA application to determine which factors have the greatest influence on response. Ethylene was a better predictor of final fruit drop than changes in fruit size for all varieties tested. However both performed very well. The ethylene bioassay requires more equipment, but the response is more immediate. Bourse, and spur leaves as well as fruit were capable of producing ethylene in response to NAA application. Thinning response was greatest when all leaves and fruit were treated with NAA, followed by the bourse and spur leaves. Little or no response was produced when the fruit alone were treated. Concentration experiments and radioisotope data indicate that ethylene response is directly related to the amount of NAA absorbed. Regression analysis indicates that approximately 60% of the variation in response can be predicted by ethylene evolution.

INFLUENCE OF HYDROGEN CYANAMIDE AND WILTHIN ON BLOSSOM THINNING OF APPLE AND PLUM.

Esmail Fallahi* and Brenda R. Simons, Department of Plant, Soil and Entomological Sciences, University of Idaho, 29603 U of I Lane, Parma, ID 83660.

Max W. Williams, USDA-SEA, 1104 N. Western, Wenatchee, WA 98801.

Effects of hydrogen cyanamide and Wilthin on blossom thinning and the consequences of thinning on fruit set, yield and fruit quality of 'Rome Beauty' was studied. A full bloom application of hydrogen cyanamide at the rate of 0.25% (Dormex formulation) or 0.25% of Wilthin both followed by a fruit thinning by Sevin + NAA effectively thinned mature trees of 'Rome Beauty' and had a similar effect on fruit set, yield and fruit quality. The effects of these two chemicals at these rates on several aspects of fruit set, yield and quality were similar to the effects of Elgetol. Hydrogen cyanamide, Elgetol and 0.25% Wilthin at full bloom resulted in a higher percentage of single fruit set, thus, less labor for hand thinning. Application of 0.37% Wilthin at 20% bloom or at full bloom resulted in larger fruit size, but induced fruit russeting. Soluble solids of fruit from trees with Elgetol, 0.37% Wilthin at 20% bloom or at full bloom were higher than fruit from other treatments. Hydrogen cyanamide at 0.50% resulted in a satisfactory level of blossom thinning in 'Friar' plums.

HYDROGEN CYANAMIDE BLOSSOM THINNING OF PEACHES AND APPLES

J. W. Worthington, Calvin G. Lyons* and John A. Lipe, Department of Horticultural Sciences, Texas A&M University, College Station, Texas 77843.

This research was set up to determine the effectiveness of hydrogen cyanamide as a bloom thinner on peaches and apples. When applied at full bloom hydrogen cyanamide at 0.5 to 1% was effective at reducing fruit set on several

varieties of peaches and apples in two different years. Yields were not effected when the lower rates were used. These results indicate that hydrogen cyanamide holds potential as a bloom thinner for both stone fruit and apples when used at the proper rates and timing.

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DEVELOPMENT OF A FORECAST SYSTEM FOR GROWTH REGULATOR (HYDROGEN CYANAMIDE) APPLICATION ON PEACHES USING A COMPUTERIZED AGRICULTURAL WEATHER PROGRAM

Arlie A. Powell*, Karl Harker, Roger Getz and Eugene H. Simpson, Alabama Cooperative Extension Service and National Weather Service, Auburn University, AL 36849

In order to provide timely weather information to county agents (CEA) and growers, a sophisticated user friendly weather information program was developed that provides over 900 weather files daily to users. This program uses a 420 Sun Server that automatically downloads files from the NWS office on the AU campus and makes them instantly available to CEA offices via the Extension Network. Growers may obtain information from CEAS or use their personal computers to access a "Weather Board". A chilling/growing degree hour (GDH) model (mod. 45) has been developed for peaches that provides a good estimate of when rest is completed and allows prediction of phenological stages through flowering. This information assists growers with orchard management decisions. Studies with peaches were conducted using the chilling/GDH model to properly apply hydrogen cyanamide (Dormex) to replace lack of chilling. This work resulted in an effective application timing based on chilling accumulation and allowed development of a forecast model for grower use.

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BLOOM THINNING WITH ARMOTHIN®, AN AKZO SURFACTANT

Dean R. Evert*, Horticulture - Coastal Plain Experiment Station, University of Georgia, Tifton, GA 31793-0748

Armothin® thinned *Sentinel* fruit on peach trees (*Prunus persica* L.) in 1993. Thinning increased as Armothin® rate in the single spray increased from 1.5X, to 3.0% to 6.0% (v:v) and as the percentage of open blossoms increased from 30% to 61%. The 1.5 % rate of Armothin® thinned significantly only on the third date, and the 6.0% rate overthinned slightly on the third date. Minor discoloration developed on the expanding leaves of a few of trees but disappeared in a few days. No leaf abscission occurred on treated trees and tree growth was normal. Variability between trees treated alike probably reflects the variability in bloom when sprayed. According to Akzo, Armothin® prevents pollination by reacting with the surface of the receptive stigma. Spraying after full bloom should selectively prevent fertilization of the last blossoms to open without destroying the fertilized fruit. This possibility will be tested in 1994. Armothin®, which is a contact thinner, seems to avoid the problems associated with thinners that act as growth regulators and with nonselective caustic thinners. Because of its low phytotoxicity and wide range of effective rates, Armothin® has great potential as a chemical thinner.

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EFFECTS OF DORMANT APPLICATION OF SOYBEAN OIL ON PEACH TREES

R.E. Myers*, D.E. Deyton, and C.E. Sams, Department of Plant and Soil Science, The University of Tennessee, Knoxville, TN 37901-1071.

'Redhaven' peach trees at the Knoxville Experiment Station were sprayed to runoff on 3 February 1993 with single applications of 0, 2.5, 5.0, 10.0, or 15.0% (v/v) degummed soybean oil with 0.6% Latron AG 44M emulsifier. Treatments were arranged in a randomized complete block design with 6 single tree replications. The internal CO₂ concentration of treated twigs was elevated the first day and continued to be significantly higher than the control through the fifth day following treatment. Respiration rates of soybean oil treated buds-twigs were lower than the control for the first eight days after treatment. Flower bud and bloom development were delayed by treatment of trees with 5.0 to 15.0% soybean oil. Treatment with 5.0% oil delayed bloom approximately 4 days. The greatest delay (approximately 6 days) occurred after treatment with 10.0 or 15.0% oil. Yield was reduced and fruit size increased as the concentration of soybean oil was increased. Optimum fruit size was achieved with the 5.0% soybean oil treatment.

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SEASONAL VARIATION IN THE RESPONSE OF ENDODORMANT PEACH TO BIOREGULATORS AND THEIR INTERACTION WITH ETHYLENE

William C. Mitchell* and Gregory A. Lang, Department of Horticulture, Louisiana State University, Baton Rouge, LA 70803

Fall application of 2-chloroethylphosphoric acid (ethephon) is known to delay spring budbreak in peach (*Prunus persica*). To study seasonal variation in peach response to dormancy-breaking plant bioregulators and their possible interaction with ethylene, peach shoots were cut in the field at various intervals during endodormancy. Shoots were dipped in the dormancy-breaking bioregulators hydrogen cyanamide (H₂CN₂, 100 mM) or gibberellic acid (KGA₃, 130 µM), alone or in combination with 1.38 mM ethephon. Treated shoots were held in beakers of either tap water or 1 mM silver thiosulfate (STS), and placed in growth chambers with potassium permanganate traps, 12/12 h photoperiods and 21/26 °C temperature regimes. Dormancy-breaking efficacy (apical budbreak at 21 days) of both bioregulators increased as endodormancy progressed. At all intervals, H₂CN₂ broke dormancy more effectively than KGA₃. The addition of ethephon to H₂CN₂ application prior to any CU accumulation (20 Oct) had no effect on efficacy (80% budbreak), but its addition after accumulation of ~50 CU (8 Nov) or ~320 CU (14 Dec) reduced subsequent budbreak to 25% and 40%, respectively. The addition of ethephon to KGA₃ applications reduced budbreak both prior to (27 Oct) and after (8 Nov) initial CU accumulation. STS in the beaker solution increased both the extent (27 Oct) and the rate (14 Dec) of KGA₃-induced budbreak. The interaction of ethylene, bioregulator type, and endodormancy regulation will be discussed.

85 ORAL SESSION 27 (Abstr. 192-199) Ornamentals: Stress

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EXPOSURE TO ULTRAVIOLET-B RADIATION INCREASES COLD HARDINESS IN RHODODENDRON

Chris A. Dunning, Linda Chalker-Scott*, and James D. Scott, Department of Biology, SUNY College at Buffalo: 1300 Elmwood Avenue, Buffalo, NY 14222-1095

The change in the cold hardiness of *Rhododendron* (cv. 'English Roseum') following chronic exposure to ultraviolet-B radiation (280-320 nm) was studied. Leaf disks removed from ultraviolet-B exposed plants exhibited a greater tolerance to freezing temperatures than plants which received no ultraviolet-B exposure. Visual browning and percent phenolic leakage indicated that UVB-exposed leaf disks were killed at -11 °C, while control disks were killed at -8 °C. The increase in phenolics seen in UV-B exposed plants most likely contributed to their increased resistance to cold temperature through the synthesis of cell-wall associated components such as lignin and suberin.

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COLD HARDINESS OF *CORNUS ALBA* 'ARGENTEA MARGINATA' AND *WEIGELA FLORIDA* 'RUMBA' GROWN UNDER DIFFERENT FALL FERTILIZATION PROGRAMS.

Isabelle Duchesne*, Jacques-André Rioux and Michèle Beaudry, Université Laval, Pav. Environron, Cité Universitaire, Sainte-Foy (Qc), G1K 7P4, Canada. Effects of fall fertilization programs on cold hardiness of young *Cornus alba* 'Argenteo-Marginata' and *Weigela florida* 'Rumba' plants, were examined. In August 1992, four fertilization programs were applied to one year old woody plants, propagated by cuttings in 1991. Fertilization treatments were as follows: 1. discontinuation of fertigation treatments on August 30; 2. gradual decreasing nitrogen concentration (100 to 0 mg/l of 20-20-20) from August 15 to September 30; 3. constant nitrogen concentration (100 mg/l of 20-20-20) from August 15 to September 30; and 4. high potassium concentration (110 mg/l of 7-11-27) from August 15 to September 30. Whole plants were removed from pots and roots cleaned. They were placed under freezing temperatures ranging from 0 to -20°C at 2°C intervals. Sampling were taken at the end of September, October and November. After the freezing test, the plants were stored at -2°C. re-potted in May 1993, and evaluated for winter injury in August 1993. Results indicate that none of the four fertilization programs induced positive or negative effects on cold hardiness in both species. However, the signs of cold hardiness are observable in October at different degrees in each species. Plants of *Weigela* died at -12°C, while all plants of *Cornus* survived down to -20°C. Furthermore, a 25% loss of growth of stems and roots was found at -9°C for *Weigela*, while for *Cornus* it was -17 and -15°C stems and roots respectively.

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COLD HARDINESS AND CARBOHYDRATE CONTENT OF FOUR CULTIVARS OF FIELD-GROWN SOUTHERN MAGNOLIA
C.L. Haynes*, O.M. Lindstrom, M.A. Dirr and R. Severson, Department of Horticulture, University of Georgia, Athens, GA 30602-7273

Cold hardiness and carbohydrate content of 4 cultivars of field-grown southern magnolia (*Magnolia grandiflora* L.) were determined monthly during the 1992-1993 winter. Initially, 'Claudia Wannamaker', 'Little Gem', 'Timeless Beauty', and 'Victoria' had similar stem and leaf cold hardiness estimates of -6C in October. However, by February 'Claudia Wannamaker' and 'Victoria' stems were 6 and 3C more cold hardy than 'Little Gem' and 'Timeless Beauty' stems. 'Claudia Wannamaker' leaves were also 6C more cold hardy than 'Little Gem' and 'Timeless Beauty' leaves in February. Carbohydrate analysis indicates increases in oligosaccharides during cold acclimation in fall.

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PHYSIOLOGICAL STUDY OF HEAT TOLERANCE IN RHODODENDRON SPP.

Thomas G. Ranney*, Frank A. Blazich, and Stewart L. Warren, Department of Horticultural Science, North Carolina State University, 2016 Fanning Bridge Rd., Fletcher NC 28732

Temperature sensitivity of net photosynthesis (Pn) was evaluated among 4 taxa of rhododendron including *Rhododendron hyperythrum*, *R. russatum*, and plants from two populations (northern and southern provenances) of *R. catawbiense*. Measurements were conducted on individual leaves at temperatures ranging from 15 to 40C. Temperature optima for Pn ranged from a low of ~21 C for *R. russatum* to a high of ~27C for *R. hyperythrum*. At 40C, Pn rates for *R. hyperythrum*, *R. catawbiense* (northern provenance), *R. catawbiense* (southern provenance), and *R. russatum* were 7.8, 5.7, 3.5, and 0.2 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, respectively. *R. catawbiense* from the southern provenance did not appear to have greater heat tolerance than plants from the northern provenance. There was no difference in temperature sensitivity of dark respiration among the taxa. Variations in heat tolerance among species appeared to result from a combination of stomatal and nonstomatal limitations on Pn at high temperatures.

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EFFECTS OF DROUGHT AND ROOT-ZONE TEMPERATURE ON GROWTH AND WATER RELATIONS OF SILVER MAPLES FROM FIVE PROVENANCES

Anthony S. Aiello* and William R. Graves, Department of Horticulture, Iowa State University, Ames, IA 50011-1100
John E. Preece, Department of Plant and Soil Science, Southern Illinois University, Carbondale, IL 62901

Along with its horticultural uses, silver maple (*Acer saccharinum* L.) can be grown for biomass in areas that vary greatly in annual rainfall and temperature. Silver maples from five provenances ranging from 33 to 46° N latitude were subjected to drought stress and to high root-zone temperature (RZT) in separate experiments to assess their suitability as biomass sources. In the drought experiment, control plants were irrigated every 2 days, while stressed plants were irrigated every 15 days. Initial results indicated provenance differences among control plants in dry mass, leaf area, and transpiration. Drought reduced growth and mitigated differences among provenances. Osmotic potential of leaves was higher in control plants than in drought-stressed plants. Plants from two provenances (33 and 44° N) were grown with RZT of 24 and 34 C for 3 weeks. Gain in fresh mass over time was reduced at 34 C for plants of both origins, but plant dry matter and leaf surface area were similar at the two RZT. Data collected to date suggest resistance to drought and high RZT is similar in plants of different provenances.

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ENERGY BALANCE OF URBAN SURFACES AFFECTS GAS EXCHANGE OF CRABAPPLE AND NORWAY MAPLE

Roger Kjellgren* Thayne Montague and Larry Rupp, Dept. Plant, Soils, and Biometeorology Utah State University, Logan, UT 84322

We investigated gas-exchange response of norway maple and crabapple to the energy balance of turf, bark-mulch, and asphalt surfaces. In each surface stomatal conductance, leaf temperature (T_l), and photosynthesis, were measured during two dawn-to-dusk studies concurrent with soil (T_s), top surface (T_s), and air temperature (T_a) measurements. Different properties affected the energy balance of each surface. Turf transpiration moderated T_s and T_l while low thermal conductivity of the mulch resulted in T_s similar to turf but T_l 23C higher. Higher thermal conductivity of the asphalt resulted in higher T_s but T_l intermediate to mulch and turf surfaces. We did not detect differences in T_s probably due to close proximity to one another that allowed

substantial air mixing between treatments. Higher T_s increased longwave radiation flux that raised midday T_l of trees in the mulch and asphalt 3 to 8C higher than trees in the turf. Differences in T_l between the asphalt and mulch were minimal. Stomatal conductance declined with increasing leaf-to-air vapor pressure gradient in all trees, and was consistently lower for trees in the mulch and asphalt through the day due to larger gradients induced by higher T_l. Midday photosynthesis was highest for trees in the turf and lowest for those in the mulch. Foliar interception of higher energy fluxes from mulch and asphalt surfaces apparently limited gas exchange in both species due to over-optimal leaf temperatures as compared to trees in the turf

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EVALUATION OF DROUGHT TOLERANCE OF *Fragaria chiloensis* CLONES WITH POTENTIAL AS LOW-MAINTENANCE ORNAMENTAL GROUNDCOVERS

Ann Marie VanDerZanden* and J. Scott Cameron, Washington State University Research & Extension Unit, 1919 NE 78th Street, Vancouver, WA, 98665.

Fragaria chiloensis (Linnaeus) Is a viable, low maintenance alternative to groundcovers currently available in the ornamental landscape industry. There is considerable genetic variability within this species for leaf morphology, growth and flowering habits as well as drought tolerance. Clones collected from 11 coastal sites in CA and OR were compared for drought tolerance after two imposed water stress/recovery cycles. Predawn water potential, gas exchange, chlorophyll (chl) content, fourth derivative spectroscopy, carbon isotope discrimination, and total biomass production were evaluated and significant clonal differences were observed.

Predawn water potentials after the first stress cycle ranged from -35.0 MPa to -6.5 MPa. Clones I05, DNT and G19 had highest predawn water potentials and gas exchange rates after both stress cycles. In the control group, I05 and DNT had higher levels of chl a, chl b, total chl and chl a/b. After the first stress cycle, clones DNT and I05 had the highest chl a/b ratio, however, after the second stress event there were no differences in any chl parameters. Varying adaptive abilities observed may suggest differential use in the landscape.

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A PERFORMANCE EVALUATION ON TWELVE SPECIES OF ORNAMENTAL GRASSES UNDER WATER STRESS IN GREENHOUSE AND FIELD CONDITIONS

June Wolfe III*, J.M. Zajicek, and M.A. Hussey

Departments of Horticultural Sciences and Soil & Crop Sciences, Texas A&M University, College Station, Texas 77843-2133

Six native Texas and six introduced ornamental grass species were chosen for an evaluation of water use performance and aesthetic value under drought stress to identify material most appropriate for water conserving landscapes. Greenhouse and field experiments determined the overall performance of the grasses under drought conditions. A public survey evaluated the aesthetic value of investigated species. Greenhouse work determined that examination of total chlorophyll content was not a useful parameter for predicting drought stress. Water use and visual aesthetic decline rates were determined for all species in the greenhouse. On average, native and introduced species performed equally well. *Imperata cylindrica* exhibited the lowest rates of water use (by 92%) and visual decline (by 51%) in the greenhouse and was the most conservative water user in the field with lowest stomatal conductance (by 76%). The survey found that grasses were acceptable as ornamentals in the landscape and natives and introduced species equal in preference.

86 ORAL SESSION 28 (Abstr. 200-205) Berries: Culture and Management

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STRAWBERRY PRODUCTION IN THE DESERT OF KUWAIT

Mahdi S. Abdal and Majda K. Suleiman *, Kuwait Institute for Scientific Research, P.O.Box 24885, Safat 13109, Kuwait.

The climate of Kuwait can be characterized as hot (maximum in excess of 45°C), and dry during the summers (May to October), with high evaporation (16 mm/d). Night-time temperatures also remain relatively high during these summer months. Rainfall over the course of the year is very low, usually being limited to less than 100 mm, which falls primarily during the winter months. Likewise, while the country's sand and dust storms occur primarily during the summer months, there may be occasional flurries at almost any

time during the year, causing major additional problems with unprotected production of sensitive food crops, like strawberries. Water is also one of the country's most limiting resources, with all ground-water being highly brackish.

Strawberry production, on a commercial basis is a relatively new development in Kuwait. Pre-war production (under protected and unprotected environments) had increased to over 125 tons, on approximately 5 ha of land, providing about 75% of the then existing demand. Strawberry growers set their plants in November and harvest fruit in May. If production could be maintained on a year round basis, at high quality levels, demand would presumably also be significantly higher. While yields had increased to about 25 tons per hectare, production problems include pests (including aphids), cultural practices and adapted cultivars. Current and planned work will be discussed.

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ALTERNATIVE WEED CONTROL STRATEGIES FOR STRAWBERRIES IN THE ESTABLISHMENT YEAR

Charlotte Herman* and Emily Hoover, Department of Horticultural Science, University of Minnesota, St. Paul, MN 55108

The objective of our study was to establish first year strawberry plantings without using herbicides. 'Honeyoye' transplants were set into plots measuring 6.1m X 7.32m on 21 May, 1993. Four treatments were established: winter wheat, a dwarf Brassica sp., napropamide (2.24kg/h), and no weed management. After the strawberry plants, cover crops (and some weeds) were fairly well established, (18 June) 6 week-old African "weeder" geese were put into half of each plot to graze. Weekly data was taken on the percentage of soil area covered with plant material, height and stage of development of plants, and weeds present. A weed transect was done in 6 July. Plant material was collected from each plot on 26 July and 16 Sept. in a 0.2m² area, and dried. The most promising cover crop treatment was the dwarf Brassica for early season weed control. However, the herbicide treatment with no geese produced the best strawberry plant growth.

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THE USE OF RYE, WHEAT, AND CRIMSON CLOVER FOR WEED SUPPRESSION IN 'CARDINAL' STRAWBERRIES

Julia Whitworth, Dept. of Horticulture & L.A., Oklahoma State University. Wes Watkins Agri. Research and Extension Center, Lane, OK 74555

Rye, wheat, and crimson clover were planted in separate pots outdoors in the fall of 1992 and 1993. Control pots had media without plants in them. There were 4 replications in 1992 and 9 in 1993. In early spring, the rye, wheat, and crimson clover were killed, using tillage in 1992 and glyphosate in 1993. In 1992, the residues were tilled into the media. In 1993, the residues were left on the surface. 'Cardinal' strawberries, yellow nutsedge nutlets, crabgrass seeds, or bermudagrass rhizomes were planted into pots with the various residues, and also into the control pots. In July of 1992 and August-September of 1993, the weeds and strawberry plants were removed from the pots. Various growth measurements were taken on the plants. None of the tilled residues affected the growth of nutsedge or crabgrass, but tilled rye and wheat residues increased the growth of strawberry plants and decreased the growth of bermudagrass. None of the residues left on the surface significantly affected the growth of crabgrass. Clover residues suppressed nutsedge growth. Both strawberry and bermudagrass growth was greatly reduced by all surface residues.

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ETIOLOGY OF STRAWBERRY BLACK ROOT ROT

Katherine Wine and Marvin Pritts*, Dept. of Fruit and Vegetable Science, Cornell University, Ithaca, NY 14853

Black root rot is a devastating, poorly understood disease complex affecting strawberries throughout the world, especially in perennial plantings. Field measurements at 54 sites in New York were made for 113 cultural and environmental variables, and root health was quantified. Root health was negatively associated with wet, compacted soils where plants were grown for several years on flat beds with terbacil herbicide. *Pratylenchus penetrans* numbers were associated with rotting roots, but not in all sites. *Rhizoctonia fragariae* and *Pythium* spp. were usually isolated where black root rot was present, but not always. When strawberry plants were grown in infested soil at warm temperatures (23C), *R. fragariae* was most commonly isolated, and when grown in the same soil at cool temperatures (5C), *Pythium* was found. Inoculation of sterile soil with *Pythium* and/or *Rhizoctonia* reduced root dry weights, but symptoms were not identical to those observed in the field. Various combinations of pathogenic fungi, nematodes, soil compaction,

flooding, low light and terbacil failed to recreate field symptoms in the laboratory. Tolerance rankings of 20 cultivars were different at four field sites. These observations suggest that black root rot can have many causes, and that susceptibility may be stress induced under field conditions.

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POTENTIAL OF BLOWN AIR AS A THIGMIC STRESS FOR TEMPORARY NONCHEMICAL PRIMOCANE SUPPRESSION OF RED RASPBERRY

T. Kostman*, J.S. Cameron, C. Chen, and S. F. Klauer. Washington State University Research & Extension Unit, 1919 NE 78th St, Vancouver, WA, 98665.

The red raspberry industry of the Pacific Northwest depends upon chemical primocane suppression to temporarily reduce competing vegetation during fruit development. This practice increases yield and harvest efficiency, but can reduce cane vigor, number and diameter over time. Few chemicals are available for this purpose and thus the potential of nonchemical alternatives is being explored. The purpose of this project was to evaluate the potential of blown air as a thigmic stress to temporarily suppress primocane growth.

Blown air treatments were applied once (12 PM) or twice (12/4pm) per day, five days per week using a portable leaf blower generating winds of 273 km per hr. Treatments also included several rates of three experimental herbicides and an untreated control. All treatments were applied when primocanes were 10-15 cm in length and blown air treatments continued through fruit development. Primocane development was monitored over the course of the season.

Blown air reduced primocane length by 15-30% prior to harvest giving control equivalent to current chemical methods. Blown air increased cane diameter but reduced yield by reducing fruit numbers. Reductions in fruit numbers are likely due to flowering/fruitlet points removed by blown air.

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THE WASHINGTON STATE CRANBERRY VARIETY 'MCFARLIN': YIELD AND COMPONENTS OF YIELD VARIATION

Nicholi Vorsa*, Kim Patten and Richard Novy', 'Blueberry and Cranberry Research Center, Rutgers University, Chatsworth, NJ 08019, and 'Washington State University-Long Beach Research and Extension Unit, Long Beach, WA 98631

WA State bogs of the cultivar 'McFarlin' exhibit highly variable productivity. Yield and various fruiting characteristics were sampled in 14 WA 'McFarlin' bogs, representing two growing areas. Significant differences were found for yield, fruit number/area, percent fruit set, flowers/upright, fruit/upright, fruit weight and seed number/fruit. The variable, flowers/upright, accounted for 69% and 75% of the observed variation for yield and fruit number/area, respectively. A multivariate analysis model accounted for 93% of the variation for yield with 3 variables: flowers/upright (69%), fruit weight (20%), and seed number (4%). Principal component analysis identified three 'groups' based on fruiting characteristics. DNA fingerprinting suggests, that variability in yield and fruiting characteristics, has a genetic component.

87 ORAL SESSION 29 (Abstr. 206211) Cross-commodity: Extension

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HORTICULTURAL SCIENCE AND FORENSIC SCIENCE: THE POTENTIAL CONTRIBUTION OF HORTICULTURAL SCIENTISTS AT CRIME SCENES

J. Scott Cameron*. Washington State University Research & Extension Unit, 1919 N.E. 78th St., Vancouver. WA 98665

The criminal justice system is served by many experts who provide special assistance to law enforcement professionals during criminal investigations. One of these specialized areas, forensic botany, has traditionally been an activity of the systematic botanist who identifies plant material associated with a suspect or crime scene. From this information, suspects can be placed at crime scenes and information such as time of death or movement of victims can be determined. Few plant scientists are involved in this emerging field which has the potential to make contributions similar to those made today by forensic anthropology.

Plant scientists with training in systematic botany, plant anatomy, plant

growth and development, and statistics and probability can make significant contributions to criminal investigations. The use of plant identification and plant growth analyses In recent criminal Investigations will be described. The role of horticulture in the future of forensic science and the development of new techniques In forensic plant science will also be discussed.

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TASK ANALYSIS IN STONE FRUIT FREEZE PROTECTION DECISION SUPPORT SYSTEM DEVELOPMENT.

Michael J. Willett*, Preston K. Andrews, and Edward L. Proebsting, Jr., Department of Horticulture and Landscape Architecture, Washington State University, Pullman, WA 99164-6414.

There has been an explosion of interest in the development of computer-based Decision Support Systems (DSS) in agriculture. Humans factor, which is the design and evaluation of a system to optimize human and total system performance, offer tools to improve the usefulness of DSS. Task analysis, a formal human factors approach to study human-machine interaction, identifies all of the physical and psychological tasks which must be completed by either the human or the machine in order to meet the various system performance requirements and constraints. Our study focuses on the tasks associated with mid-winter stone fruit freeze protection. Using this technique we have identified work load and output requirements of current critical temperature estimation procedures, additional information needed to improve critical temperature estimates and training needs of fruit industry personnel making critical temperature determinations. This information will be used to produce a requirements specification for a freeze protection DSS.

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EXTENSION SERVICES LINK INDUSTRY TO RESEARCH

Nancy Beck* and Jim Kerr*, HortResearch, The Horticulture and Food Research Institute of New Zealand, Private Bag 11030, Palmerston North, New Zealand.

The restructuring of government research and extension organisations within New Zealand provides a rare opportunity to reshape our approach to technology transfer. This paper describes the approaches which HortResearch is taking to develop its technology transfer activities and extension services to New Zealand's horticultural industries.

Research is without purpose if the resultant technology is not transferred from scientists to growers and other industry groups and vice versa. Effective research planning in HortResearch and the provision of decision support information to growers, will depend on good working links between researchers and other key industry players. Rapid development of this linkage is crucial due to the loss of the traditional free extension service in the restructuring process.

A working party assessed the industry's needs and concepts of technology transfer. A workshop to discuss technology transfer option was held with key people from the horticultural industry; this was followed later by an in-house workshop. Proposals for the Institute to establish link teams for each horticultural sector were the outcome.

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THE WASHINGTON TREE FRUIT MANAGEMENT PROGRAM

Paul Tvergyak* and Mark K. Mullinix, WSU Cooperative Extension, 400 Washington, Wenatchee, WA 98801-2855

To address the acute need of Washington's tree fruit industry for professional horticulturists, the Agriculture Sciences Department at Wenatchee Valley College and the Department of Horticulture and Landscape Architecture at Washington State University have developed and implemented a unique undergraduate degree program. This program represents a new way of addressing the need for professional horticultural positions in Washington's tree fruit industry amidst tradition, reductions in state higher education budgets, and eroding confidence in the public education system. This program is not a credit transfer program but a fully articulated agreement. We established a small working team that represented the partners. Their goal was to discuss and develop a concept framework that has three parts: administrative, curriculum and industry support. The objectives of the program are to address the need of Washington's tree fruit industry for entry level horticulturists who could assume more responsibility earlier in their career, to make the fruit industry and integral partner, to prepare students for graduate study as well as industry professionals and to capitalize on the respective strengths of the partners.

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CUSTOM-PRINTED ELECTRONIC FACT SHEETS AT HORTICULTURAL EVENTS

Charles Marr, Horticulture Div., Waters Hall, Kansas State Univ., Manhattan, KS 66506-4029

A series of 62 fact sheets on a variety of topics related to vegetable gardening were constructed in WordPerfect and, using a series of macros and styles, were modified to a standard format and printed to a file for storage. Sheets were organized into a heirarchal menu so they could be copied to the printer upon request using only DOS commands. A portable laptop computer and a Hewlett Packard Portable DeskJet printer was used to print files at such remote locations as nurseries/garden centers, shopping malls, fairs, and public events where Master Gardener volunteers set up and operated the equipment. Single sheets could be printed in about 20 seconds. At garden shows with larger attendance, a HP Laser 4 printer and a standard computer were used to print fact sheets at about 5 seconds each. Fact sheets consisted of text and tables but no graphics were included. Most sheets were single pages although several were 2 pages in length. Additional information was available from a comprehensive for-sale publication sold or available for ordering on-site. Costs of custom printed fact sheets compared to standard printing will be discussed.

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AN EXPERT SYSTEM FOR URBAN TREE SELECTION

Edward F. Gilman Environmental Horticulture Department, University of Florida, Gainesville, FL 32611

This computer program, delivered-on a CD-ROM disc, develops a list of tree species and cultivars suited for a specific planting site. It requires little previous computer experience or tree knowledge to operate. Using multiple choice questions, the program automatically brings the user through above ground and below ground site analysis. This includes all the considerations known to influence proper species selection for a planting site. Using C++ programming and the NASA-developed expert system shell called CUPS, a list of facts is generated as the user answers the questions. At the press of a button, the program finds trees that match the attributes the expert system placed on the facts list. The list can be further modified by choosing among ornamental and other tree attributes that might be of interest to the user. The tree list can be printed in several seconds. A typical run through the expert system takes 2 to 4 minutes to answer about 20 to 25 questions. The program contains data on 681 trees, more than 1,800 color photographs, and a 4-page fact sheet including 3 line drawings for each tree totaling more than 2,000 pages. The program can also be used as a reference by paging through the tree records to find information about specific trees. Each tree record lists on the computer monitor a large variety of data for the tree, allows you to view text about the tree, displays a line drawing of the entire tree, and displays up to seven photographs of each tree. The program will be distributed nationwide as a tool to help landscape architects, horticulturists and others select the right tree for the right place.

88 ORAL SESSION 30 (Abstr. 212218A)

Vegetables: Culture and Management I

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FIELD TESTS OF METHANOL AS A CROP YIELD ENHANCER.

Milton E. McGiffen, Jr.*, John Manthey, Aziz Baameur, Robert L. Greene, Benjamin A. Faber, A. James Downer, and Jose Aguiar, University of California Cooperative Extension and USDA-ARS

A 1992 article by Nonomura and Benson (Proc. Natl. Acad. Sci. 89:9794-979X) reported increased yield and drought tolerance in a wide range of C₃ species following foliar applications of methanol. The article was widely reported in the trade and popular press, which created a huge grower demand for information on the use and efficacy of methanol. To test the validity of the reports, we applied methanol with and without nutrients to a wide range of crops across California following Nonomura and Benson's (1992) protocol. Crops included watermelon, creeping bentgrass, lemons, savoy cabbage, carrots, romaine lettuce, radish, wheat, corn and peas. Environments included the greenhouse and field tests in coastal, inland valley, and desert locations. To test whether methanol improved drought tolerance, the savoy cabbage and watermelon experiments included both reduced and full irrigation. In no case was yield increased or drought tolerance attributable to methanol treatment. In some cases, methanol caused significant injury and decreased yield.

A COMPARISON OF STRATEGIES FOR SCHEDULING IRRIGATION OF VEGETABLES

Eric H. Simonne* and Joseph M. Kemble, Dept. of Horticulture, Auburn University, AL 36849-5630 and Doyle A. Smittle, Coastal Plain Experiment Station, Horticulture Dept., Tifton, GA 31793

The effect of irrigation scheduling method (variable crop factor, 1; constant crop factor, 2; empirical, 3), soil water tension (25, 50, 75kPa SWT), tillage (disc arrow, DA, moldboard plow, MP) and planting dates (PD) on total irrigation (TI), number of irrigations (NI), useful (UR) and lost rainfall (LR) was studied using a Pascal program that simulated water budgets of 720 crops of snap bean over 10 years. NI and TI were significantly ($p<0.01$) lower with met.1. Met.3 had the lowest LR and highest UR, but did not allow the complete calculation of the water balance. TI was significantly higher at 25kPa. MP tillage requested fewer NI and less TI, had lower LR and higher UR. Early PD requested fewer NI and TI, and had higher LR. Hence, when water supply was not limiting and weather data were available, a combination of Met.1, MP at any PD provided a continuous supply of water to the crop while controlling water deficit.

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LIVING-MULCH AND GENOTYPE EFFECT ON THE PRODUCTIVITY AND GROWTH OF EGGPLANT.

Hector R. Valenzuela* and Joseph DeFrank, Dept. of Horticulture, 3190 Maile Way, University of Hawaii at Manoa, Honolulu, HI 96822.

Living mulches offer a low-input alternative to achieve weed control while minimizing herbicide applications, decreased fertilizer leaching, insect and nematode management, and improved soil texture. A study was conducted to evaluate the effect of a Rhodes Grass (*Chloris gayana* cv. Katambora) living mulch on the growth and productivity of ten eggplant. *Solanum melongena*, cultivars grown under fertigation. The living sod was established at the Univ. Hawaii Waimanalo Experiment Station in June 1992. Soil analysis was taken before experiment initiation. Ten eggplant cultivars were transplanted on both living-mulch and control (woven-polyethylene mulch) plots on 4 March 1993. Weekly or bi-weekly harvests were conducted for six months, beginning on 19 May 1993. In addition plant height and canopy dimensions were determined on 16 April and 10 Nov. Plant growth was monitored throughout the experiment. Soil samples were taken from the eggplant rhizosphere, hare-ground and in Rhodes grass monoculture, for nematode count determinations. Soil samples were also taken for nutrient determination after completion of the experiment. Overall yields were greater in the polyethylene mulch than in the living mulch plots. A differential response was observed on the response of cultivars to cropping system. However the most vigorous cultivars performed well in both systems. The living mulch system showed potential for nematode management in eggplant agroecosystems.

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THE INFLUENCE OF SWEETPOTATO WHITEFLY MANAGEMENT AND POTASSIUM FERTILIZATION ON YIELD AND IRREGULAR RIPENING OF TOMATO

A. A. Csizinszky* and D. J. Schuster, University of Florida, IFAS, Gulf Coast Research and Education Center, Bradenton, FL 34203

Two insecticidal spray frequencies, 0 and 3x per week, against the sweetpotato whitefly, *Bemisia tabaci* Gennadius, were evaluated at three K rates, 190, 380 and 760 kg.ha⁻¹, for their effect on whitefly population, fruit yield and incidence of irregular ripening on tomato, *Lycopersicon esculentum* Mill., cv. Sunny. Whitefly populations were reduced with three weekly sprays, but not by K rates. Early yields were best with three weekly sprays and with the highest K rate. For the season, yield of extra large (≥ 70 mm diameter) fruit was reduced with three weekly sprays and with increasing K rates. Proportions of irregularly ripened fruits were similar with either spray frequency, but were reduced at the highest K rate.

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COMPARISON OF CELERY TRANSPLANTS NUTRIENT DEFICIENCY DIAGNOSIS BY MEANS OF DRIS OR CND METHODS

Nicolas Tremblay* and Léon-Étienne Parent, Agriculture and Agri-Food Canada Research Station, 430 Gouin Blvd. St-Jean-sur-Richelieu (Que.) J3B 3E6, Canada

Celery (*Apium graveolens* var. Dulce) is a species particularly sensitive to nutritional balance. Seedlings in multicellular trays sometimes present problems that can be traced to nutritional causes. DRIS (Diagnosis and Recommendation Integrated System) and CND (Compositional Nutrient Diagnosis) are two recent concepts that can be implemented to diagnose nutritional imbalances from tissue analyses of any plant species. A data bank of 215 observations was used to elaborate DRIS and CND norms for celery transplants. The threshold yield for high yielders was set at 1600 g/plant (27% of the population). Both DRIS

and CND systems were implemented and a validation process was undertaken. Nutrient deficiencies (N, P, K, Ca, Mg, Fe, B and Zn) were induced on celery seedlings in growing chambers. Tissue samples were given balanced fertilization. The diagnosing methods (DRIS and CND) were compared on the basis of their ability to identify correctly the induced nutrient deficiencies.

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OPTIMIZING N AND P FOR ROCKWOOL-GROWN CUCUMBERS

M.K. Schon* and M.P. Compton, The Land, EPCOT, Walt Disney World, Lake Buena Vista, FL 32830

Experiments were conducted to determine the optimum levels of N and P for use in greenhouse cucumber (*Cucumis sativus* L. 'Vetomil') production. Plants were grown in rockwool slabs using a double-stem pruning method. Treatment 1 plants were fed 90 ppm N until N in the growing slabs was depleted (averaged <10 ppm); N was then increased to 175 ppm. Treatment 2 and 3 plants were given a constant 175 or 225 ppm N, respectively. Plants in all treatments depleted N in the slabs by three to four weeks after transplant (WAT); N remained low in Treatment 1, but recovered to adequate levels in Treatments 2 and 3. Phosphorus was provided at a constant 50 ppm and was depleted to <10 ppm in the slabs of all three treatments by four WAT. Fruit yield increased significantly with each increase in solution N. Similar results in a second trial indicated that N and/or P may have been limiting factors even at the highest levels tested. Research will continue to determine optimum levels of N and P for maximizing yield.

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EFFECT OF NITROGEN FERTILIZERS ON THE GROWTH AND VOLATILE OIL CONTENT OF *TAGETES MINUTA* L. PLANTS

Nadia M. Abdalla*, Ahmed A. Al-Badawy, Mohamed K. Ali and Mervat A. Abd Al-Azeem, Department of Horticulture, College of Agriculture, Minia University, El-Minia, Egypt.

Mexican marigold (*Tagetes minuta*, L.) plants were fertilized with urea, nitrokima and ammonium nitrate at the rates of 0, 25, 50 and 100 kg N/feddan (feddan = 4200 sqm). These fertilizers were added at three batches during the growing season.

The application of nitrogen fertilizers enhanced plant growth in terms of plant height, stem diameter, branch number and the dry weights of leaves, flowers and herb. Also, these fertilizers increased the volatile oil content in the leaves and flowers. The most effective fertilizer was ammonium nitrate especially when the highest rate was applied as it gave 3.87 g/plant compared to 2.28 g/plant for the control plants.

The contents of photosynthetic pigments, reducing and total soluble sugars were increased compared to the control plants.

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FURTHER STUDIES EXPLORING IRON NUTRITIONAL QUALITY FROM *AMARANTHUS* SPECIES

Anusuya Rangarajan* and John F. Kelly, Department of Horticulture, Michigan State University, East Lansing, MI 48824

Over the past few years, studies have been conducted exploring the variability in iron nutritional quality from a tropical vegetable, *Amaranthus*. In order to confirm previous iron bioavailability data, *A. cruentus*, *A. hypochondriacus* and *A. tricolor* lines were grown at the MSU Horticulture Research Center and then analyzed for total and in vitro bioavailable iron. Leaves were harvested 39 days after transplanting, washed, lyophilized and ground. Total iron levels were determined using atomic absorption spectroscopy and bioavailable iron estimates derived using an in vitro assay simulating gastrointestinal digestion. Among the lines tested, total iron concentrations ranged from 145 to 506 ppm. Bioavailable iron ranged from 44 to 70 ppm. Both the total and bioavailable iron measured were highest in *A. tricolor*, similar to results of previous years. Total iron values were lower for all of the lines than detected previously, but the range of bioavailable iron was similar to earlier work. Bioavailable iron estimated using the in vitro procedure does not appear to be greatly influenced by fluctuations in total iron content. Amaranth could provide between 44 and 70 mg Fe/100 gm fresh weight, equal to 20-35% of the daily Fe requirement for women, and 40-70% for men. Future experiments will utilize an animal bioassay to verify differences detected in bioavailable iron.

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CONSUMER HORTICULTURE: CHARACTERISTICS, TRENDS, AND IMPLICATIONS FOR EXTENSION

Denny Schrock, 1-87 Agriculture Building, University of Missouri, Columbia, MO 65211

Consumer horticulture surveys conducted 7 years apart examined the scope and trends in home horticulture in Olmsted County, MN. Master Gardener volunteers were trained to conduct the telephone surveys. Landscape horticulture was important in terms of numbers of people involved and reasons for gardening. Fewer people viewed vegetable gardening as important. Young people were less likely to garden than older ones. Lack of space was the biggest barrier to gardening.

It was concluded extension should expand newspaper and newsletter media efforts. Development of cooperative programs with garden centers and other agencies was suggested. Opportunities exist for training consumers in pesticide safety and best management practices for horticulture.

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USING A RESEARCH FACILITY FOR AN EXTENSION OUTREACH PROGRAM FESTIVAL OF COLOR

Donald H. Steinegger*, Department of Horticulture, University of Nebraska, NE 68583-0724

Most of Nebraska's population resides in the urban centers of eastern Nebraska. Traditionally, however, the Cooperative Extension Service has catered to the rural populations of the state. Now, it is imperative that the public and the legislative representatives from these urban areas learn that the research and outreach programs of the University also serve them. A Festival of Color was the vehicle for delivering this information to the urban audience, as well as to Agent Educators and Aides, Natural Resource District personnel, and other professionals, including government officials. Both professionals and the general public responded enthusiastically to the Festival's innovative use of the research site.

The educational objective was to answer the public's questions on the environment, including water quality and conservation in the landscape, and reduction of fertilizers and pesticides. Information was presented by Extension Specialists and Assistants, Master Gardeners, Natural Resource District personnel, Department of Environmental Quality, State Energy Office, and Nebraska Association of Nurserymen.

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MEASURING THE IMPACT OF A COMMUNITY GARDENING PROGRAM

William T. Hlubik* and Michael W. Hamm, Rutgers Cooperative Extension of Middlesex County and the Department of Nutritional Sciences-Cook College, New Brunswick, NJ

A comprehensive model for measuring the impact of community gardening on the physical, nutritional, and sociological structures of at-risk, urban communities is desperately needed to ensure the long-term sustainability of such programs.

This presentation will focus on the stepwise formation and implementation of an evaluation tool which was developed to fill this urgent need. The intent of the research approach is to scientifically validate the connection between community gardening and community well-being. In partnership with noted horticultural researchers, urban gardeners, dietitians, and sociologists, we have developed a statistical survey which integrates scientifically proven evaluative methods with new measurement techniques.

Preliminary findings from the first year of survey administration will be shared in order to stimulate further discussion and refinement of this particular model, and to encourage the development and implementation of scientifically-based, evaluative tools for other urban gardening and community development programs.

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LANDSCAPE PREFERENCES OF ETHNICALLY DIVERSE ADOLESCENTS

Barbara Berge and Virginia I. Lohr*, Dept. of Horticulture and Land Arch., Washington State University, Pullman, WA 99164-6414

Studies have shown that many people prefer landscapes with vegetation over those devoid of plants. Few studies have looked specifically at adolescents or people of different ethnic heritages. Understanding preferences of such groups could help in designing horticultural education programs for these populations. In this study, high school students were asked to rate their preferences for a series of plant-dominated and urban-dominated slides.

Students generally gave higher ratings to the plant scenes than the urban scenes, indicating that they preferred the plant scenes. Their preferences were similar to what would be predicted from studies with adults. Hispanic students rated urban scenes and formal plant scenes, such as a garden with sculptured shrubs, significantly higher than did Anglo students. Hispanics rated informal scenes, such as a deciduous forest with no ground cover, significantly lower than did Anglo students.

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HORTICULTURAL MANAGERS' SEMINAR: UTILIZING EXTENSION RESOURCES IN RESIDENT INSTRUCTION

J.J. Ferguson, Horticultural Sciences Department, University of Florida, Gainesville, 32611

The experience and resources of extension specialists can be utilized in resident instruction within a horticultural managers' seminar for advanced undergraduate students, drawing on application of horticultural principles in work situations and other complex issues facing agricultural managers. Guest speakers present an overview of their background, work responsibilities, management philosophy and management practices. Students interact with speakers in this informal seminar and complete written evaluations of speakers and topics for discussion in later classes. This horticultural managers' seminar exposes students to the medley of problems and opportunities facing agricultural managers, utilizes the resources of extension faculty in resident instruction and reinforces ties between commodity departments and their respective industries.

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SURVEY OF PLANT MATERIALS INSTRUCTORS

Alex X. Niemiera* and Carol E. Leda, Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0327

A survey to determine teaching methodologies for plant material courses was conducted. A total of 120 surveys was sent to horticulture programs at U.S. universities and colleges. Thirty-nine, 22, and 8 respondents taught a woody plant (W), a herbaceous perennial (HP)/annual (A) course, and a foliage plant course, respectively; 21 respondents taught a combination of these courses. The following similarities were noted for W and HP/A: 1) about 190 species per Semester were presented usually in a taxonomic order using slides as the primary teaching medium for lecture, 2) the most common student complaint was too much work and memorization, 3) the most common student compliment was the practical and useful nature of the subject matter, 4) in order of importance, plant identification, landscape value, and plant cultural aspects were emphasized. For W and HP/A, 93% and 65% of plants, respectively, were presented as landscape and arboreta specimens. Seventy percent of W courses used *Durr's Manual of Woody Landscape Plants*; 58% and 10% of HP/A courses used *Still's Manual of Herbaceous Ornamental Plants* and *Taylor's Guides*, respectively.

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USING CD-ROM COMPUTER TECHNOLOGY TO TEACH PLANT MATERIALS

Edward F. Gilman, Environmental Horticulture Department, University of Florida, Gainesville, FL 32611

Due to the high cost of color separations, few plant materials texts have photographs and line drawings showing each plant at different times of the year and at different ages. CD-ROM computer technology allows the user ready access to this information at a reasonable cost. Horticulturists at the University of Florida have developed three CD-ROM discs for use throughout the U.S. The discs contain more than 3000 pages of text, extensive morphological characteristics and plant use suggestions, in addition to more than 2000 line drawings and nearly 3600 photographs of more than 1,800 plant species. Software developed for DOS and Windows allows the student to generate customized plant lists for landscape sites. Lists can be created to match specific site

115 ORAL SESSION (Abstr. 227-233)

Tree Fruits and Nuts: Genetics/heeding/ Molecular Markers

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HYBRIDIZATION OF THE BRASSICA SELF-INCOMPATIBILITY GENE WITH HAZELNUT

Cheryl R. Hampson* and Anita N. Azarenko, Dept. of Horticulture, ALS #4017, Oregon State University, Corvallis, OR 97331

Self-incompatibility, a genetic mechanism enforcing outcrossing, is most commonly controlled by a single, multi-allelic gene, designated the S-gene. Sporophytic self-incompatibility (SSI), a form of incompatibility determined by the parent plant rather than the gametes, is present in the Brassicaceae, Compositae and other families, and also in hazelnut (*Corylus avellana* L.). Little is known about the molecular basis of SSI in plants other than crucifers. An S-gene cloned from *Brassica oleracea* (donated by Dr. June Nasrallah, Cornell University) was used to probe genomic DNA obtained from seven hazelnut genotypes. DNA hybridization was observed in cultivars 'Hall's Giant' and 'Willamette'. Gene similarity was estimated to be 70-80%.

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DIVERSITY AND PHYLOGENETIC RELATIONSHIPS OF *JUGLANS* SPECIES DETERMINED FROM NUCLEAR DNA RFLP ANALYSIS

Robert G. Fjellstrom* and Dan E. Parfitt, NFSPRC, USDA, 3450 Campus Way, Corvallis OR 97331, Department of Pomology, University of California, Davis CA 95616

RFLPs were studied in 41 populations of 13 *Juglans* species to study genetic diversity and phylogenetic relationships. 19 single locus nuclear RFLP loci were used to generate genetic distance/identity matrices based on allele frequencies. 21 probes were used to generate genetic distances and phylograms using shared-fragments with parsimony analysis. Parsimony analysis on fragment data produced a minimal length tree in general agreement with distance data trees, but with additional phylogenetic resolution resembling previous systematic studies. All analyses indicate an ancient origin of *J. regia*, which has been considered a recently derived species. A 10x difference in heterozygosity was seen among species. Genetic differentiation among conspecific east Asian populations was larger than among east Asian species. The opposite was true for American species. *J. hindsii* is classified as a distinct species and *J. cinerea* was included in section *Cardiocaryon* rather than *Trachycaryon*, from the diversity analysis.

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PHYLOGENETIC RELATIONSHIPS OF *PISTACIA* SPECIES FROM ANALYSIS OF CHLOROPLAST DNA VARIATION

Dan E. Parfitt* and Maria L. Badenes, Department of Pomology, University of California, Davis CA 95616, Instituto Valenciano de Investigaciones Agrarias, Apartado Oficial, 46113 Moncada (Valencia) Spain

PCR amplification and restriction analysis of a 3.2 kilobase hypervariable chloroplast DNA, as well as hybridization of the entire restricted chloroplast genome with tobacco chloroplast DNA probes permitted the development of a phylogeny for 10 *Pistacia* species. The genus divided into two major groups. *P. Vera* was most ancestral. *P. weinmannifolia*, an Asian species, is most closely related to *P. texana* and *P. mexicana*, new world species. The 3 sp. are more recently diverged, suggesting that a common ancestor of *P. texana* and *P. mexicana* originated in Asia. *P. integerrima* and *P. chinensis* are distinct species while species within two tertiary groups were monophyletic, *P. vera*:*P. khinjuk* and *P. mexicana*:*P. texana*. A general evolutionary trend from large to small nuts and leaves with few, large leaflets to many, small leaflets was documented. *Pistacia* had an unusually low chloroplast DNA mutation rate, more than 20x less than expected.

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MOLECULAR MARKERS FOR EARLY DETERMINATION OF SEX OF PISTACHIO SEEDLINGS

J.I. Hormaza, L. Dollo, V.S. Polito, Department of Pomology, University of California, Davis, CA 95616

The Random Amplified Polymorphic DNA (RAPD) technique was used to develop molecular markers linked to sex expression in *Pistacia vera*, a dioecious species. Progenies from two female parents ('Lassen' and 'Kerman') pollinated by a common male parent ('Peters') were studied. Two bulks of DNA were made in each cross, one from males and one from females. DNA was extracted from each bulked sample as well as from each of the contributing individuals and from 14 additional *P. vera* cultivars. Twelve hundred decamer oligonucleotide primers were used to perform DNA amplification on the bulk DNA. This analysis led to the identification of one primer (OPO08) that produces a 945 bp. amplification band present only in females and absent in males. The relationship between band presence and female sex expression was conserved in every individual obtained from the two crosses and in 14 cultivars unrelated to the crosses. This band, which we propose is tightly linked to the gene(s) controlling sex determination, provides a reliable marker for sex of pistachio seedlings and should be a useful tool in pistachio breeding.

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A COMPARISON OF GENOMIC AND MORPHOLOGICAL EVALUATION FOR SELECTION IN INTERSPECIFIC BACKCROSS POPULATIONS OF WALNUT

Keith Woeste*, Douglas Shaw, Gale McGranahan, Dept. of Pomology, Wickson Hall, Univ. of California, Davis, CA 95616 and Robert Bernatzky, Dept. of Plant and Soil Sciences, French Hall, Univ. of Massachusetts, Amherst, MA 01003

We characterized a population of hybrids between English walnut and Northern California black walnut (*Juglans regia* X *J. hindsii*) and their backcrosses (BC) using both genomic markers and morphological traits. ANOVA and regression methods were used on three years' data to identify a subset of five variables that describe the morphological variability among backcross populations and their parents ($R^2 = 0.89$). Genomic markers were identified using randomly amplified polymorphic DNA (RAPD). A subset of 60 markers specific to the donor species (*J. hindsii*) were scored in 50 backcrosses to estimate the percent recipient genome in each evaluated BC. The backcrosses were ranked using each method of evaluation; correlation between the ranks was 0.423 and highly significant. Each evaluation method has advantages but neither was able to reliably identify elite progeny.

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LINKAGE RELATIONSHIPS OF ISOZYME AND MORPHOLOGICAL MARKERS IN INTERSPECIFIC CROSSES OF CHESTNUT

Hongwen Huang, Fenny Dane and Joseph D. Norton
Department of Horticulture, Auburn University, Auburn, AL 36849

Linkage relations among eight isozyme genes, *Acp-3*, *Est-1*, *Est-5*, *Prx-1*, *Prx-2*, *Prx-3*, *Me* and *Adh*, and two morphological markers, *Inh*, and *Twh*, were investigated in one F_2 and two BC families of interspecific crosses between the American chestnut (*Castanea dentata*) and the Chinese chestnut (*C. mollissima*). *Inh* was found to be consistently linked with *Prx-1* and *Est-5* in all families. The order of these three genes was determined to be *lhn--Prx1--Est5*. In addition, four other gene pairs, *Acp3--Inh*, *Acp3--Prx1*, *Me--Inh* and *Twh--Inh* were found to be linked in one of the three families investigated. The four isozyme genes and two morphological marker genes were tentatively integrated into one linkage group with the following gene order *Acp3--Me--Twh--Inh--Prx1--Est5*. This study demonstrated that isozyme genes can be integrated with morphological marker genes into a single linkage map without the need for additional crosses.

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USING RAPDs TO INVESTIGATE GENE INTROGRESSION IN APPLE

Richard E. Durham¹ and Schuyler S. Korban², ¹Department of Plant and Soil Science, Texas Tech University, and Texas Agricultural Experiment Station, Texas A&M University, Box 42122, Lubbock, TX 79409; ²Department of Horticulture, University of Illinois, Urbana, IL 61801

DNA was extracted from leaves of various *Malus* genotypes and used to screen synthetic decamer oligonucleotide primers. Samples from the following two groups were bulked: 1) seven scab-susceptible apple cultivars, and 2) 15 scab-resistant apple genotypes derived by introgressive hybridization from the previous group of cultivars. A third sample

consisted of DNA extracted from *Malus floribunda* Sieb. clone 821, the original source of apple scab resistance for all genotypes in the second group. A total of 59 primers from kits A, L, and R (Operon Technologies) were screened. Amplified fragments were obtained for 93% of the primers tested, while random amplified polymorphic DNA (RAPD) fragments were detected among samples for 76% of the primers. One primer, A15, amplified a unique band in both *M. floribunda* clone 821 and the bulked scab-resistant sample. This RAPD marker, designated OA15₀₀₀, identifies an amplified, introgressed fragment that likely corresponds to a region of the genome that may serve as a modifier for the scab resistance gene block *V*, derived from *M. floribunda* clone 821.

116 ORAL SESSION 33 (Abstr. 234-240) Berries and Grapes: Postharvest

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MODERN TECHNIQUES FOR PRESERVING ROOMY RED GRAPES (VITIS VINIFERA L.).

ABDEL HAMEED WASSEL

Fac. of Agric. El-Minia University, El-Minia- Egypt.

Spraying Roomy Red grapes with benomyl 15 days before harvesting was effective than the control in decreasing decay percentage during 77 days cold storage (2-3°C). On the other hand, it was of meaningless effect on shattering and bleaching.

Adding sodium bisulfite at a rate of 0.25 and 0.50 gms/skgs fruits just before storage minimized decay and shattering percentage. Simultaneously, no significant influence could be detected concerning its influence on bleaching. Sodium bisulfite reduced losses in grapes, weight as well as total soluble solids and acidity than the control and benomyl treatments. The studied parameters in grapes treated with benomyl and sodium bisulfite as a pre and post-harvest treatment did not differ statistically than that of those treated with sodium bisulfite alone.

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ELECTRONIC SENSING OF AROMATIC VOLATILE! FOR QUALITY SORTING IN BLUEBERRIES

Meny Benady, Amots Hetzroni, James E. Simon, and Bruce Bordelon, Center for New Crops and Plant Products, Department of Horticulture, Purdue University, West Lafayette, IN 47907-1165

We have developed an electronic sensor ("sniffer") that measures fruit ripeness rapidly and nondestructively by measuring the aromatic volatiles that are naturally emitted by ripening fruit. In this study, we evaluated the potential of using the fruit ripeness sniffer in the quality sorting of blueberries. Blueberries were first visually classified into four distinct ripeness classes: unripe; half-ripe; ripe; and over-ripe and quantitatively measured for color, firmness, TSS, and sugar acid ratio. Ripeness classification accuracy with the sniffer matched or exceeded that of all other ripeness indices. The sniffer differentiated unripe, ripe and over-ripe berries within one second, but could not distinguish between the unripe and half-ripe class. Detection of 1-2 damaged or 1-2 soft fruit spiked within a large container of 24-37 high quality ripe fruit was also achieved, but required a response time of 10 seconds. Electronic sensing of aromatic volatiles may be a useful new technique in the grading and sorting of blueberries.

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RESPIRATION AND TEMPERATURE VARIATION EFFECTS ON MA PACKAGING OF STRAWBERRIES AND RASPBERRIES

P. Chowdary Talasila, Arthur C. Cameron, and Dennis W. Joles, Dept. of Horticulture, Michigan State University, East Lansing, MI 48824

Natural variation of product respiration rate and temperature variation during shipping and marketing influence the atmosphere inside MA packages. Respiration rate variation data was collected at 0C and 5.5C for 'Allstar' and 'Honeoye' strawberries and at 5.5C for 'Heritage' raspberries. Coefficient of variation was 8% for raspberries and ranged from 6.5% to 12.5% for strawberries. To determine package-to-package variations, steady-state O₂ partial pressures were measured in 100 similarly designed packages and frequency distributions were

constructed. For 'Honeoye' variety, O₂ partial pressures ranged from 3.5 kPa to 13.7 kPa with a median of 7.5 kPa in one set of packages and from 0.4 to 1.65 kPa with a median of 0.6 kPa in another set of packages with different design. Large variations were also observed for 'Allstar' variety and raspberries. The results compared well with package O₂ distributions predicted by a mathematical model that was constructed based on respiration rate variation. A modeling approach was used to predict frequency distributions and changes in gas levels in strawberry and raspberry packages for several possible temperature variation situations and for different types of package designs.

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RETENTION OF RASPBERRY RECEPTACLES DOES NOT IMPROVE QUALITY

P. Perkins-Veazie¹*, B. Strik², and J.K. Collins¹

¹USDA-ARS, South Central Agric. Res. Lab., Lane, OK 74555;

²Dept. Hort., Oregon State Univ., Corvallis, OR 97331-7304

Harvesting raspberry fruit with an attached receptacle prevents compression of the fruit in storage containers and permits harvesting of immature fruit. This study was done to determine the effects of receptacle retention on fruit quality during storage. 'Heritage' raspberry fruit from Oregon and Arkansas were harvested at light red (red ripe) and dark red stages of maturity, and stored at 2C, 95% RH for 7 days. Dark red fruit with receptacles were firmer than those without receptacles, but there were no differences in light red fruit. Ethylene production was higher from raspberries stored with receptacles. Total anthocyanin increased in all fruit after storage and was slightly higher in fruit without receptacles. Soluble solids concentration did not change but titratable acidity decreased during storage for all treatments. When fruit were harvested after several days of rain, decay incidence in fruit held with receptacles increased. Harvesting raspberries with attached receptacles did not increase postharvest fruit quality.

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EFFECT OF STORAGE INTERVALS ON QUALITY OF KIWIFRUIT (*Actinidia chinensis* Planch)

Fouad M. Basiouny

Department of Agricultural Science

Tuskegee University

Tuskegee, AL 36088

Kiwifruits at 3 stages of ripening were stored at 3°C for 4 weeks to study the effect of cold storage on ethylene production and fruit quality. Samples taken weekly were analyzed for firmness, TSS, acidity, tissue chlorophyll and carbohydrate contents. Fruits at early stage of ripening (hard) produced less ethylene than fruits at late ripening stage (soft). Fruit quality attributes vary significantly among the different ripening stages and storage intervals.

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RESPONSE OF KIWIFRUIT SOFTENING TO ETHYLENE APPLICATION

Guiwen Chene*, Carlos Crisosto and David Garner, Department of Pomology, UC-Davis, Kearney Agric. Center, 9240 S. Riverbend Ave., Parlier, CA 93648.

During the 1993 and 1994 seasons, the response of Kiwifruit (*Actinidia deliciosa* var. Hayward) flesh softening to exogenous ethylene applications was studied on fruit collected weekly from cold storage and directly from the vines. Fruit samples from both sources, were induced to ripen with and without ethylene preconditioning treatment (10 ppm, 24h at 0C).

During the first 3 weeks of fruit collection, flesh firmness decreased and SSC accumulation increased faster in ethylene treated kiwifruit than in the untreated. After this period, when kiwifruit had close to 9 pounds flesh firmness, ethylene treated and untreated kiwifruit softened at the same rate. Ethylene treatment did not enhance kiwifruit CO₂ and ethylene production except at the first harvest time. Furthermore, ethylene treated kiwifruit did not have higher respiration and ethylene rates than untreated kiwifruit when measured at 0, 5 and 20C.

RELATIONSHIP OF GROWING LOCATIONS, HARVEST MATURITY, SUMMER PRUNING, SOIL NITROGEN APPLICATION, AND STORAGE ON FRUIT POSTHARVEST PERFORMANCE IN 'HAYWARD' KIWI FRUIT

Sanliang Gu*, Carlos H. Crisosto, R. Scott Johnson, Robert C. Cochran and David Garner, University of California, Kearney Agricultural Center, 9240 S. Riverbend Avenue, Parlier, CA 93648

Fruit from 8 'Hayward' kiwifruit vineyards in central California were harvested at 2 week intervals after soluble solids content (SSC) reached 6% and subjected to 4 and 6 months of storage at 0°C in an ethylene free environment. Fruit characteristics at harvest and postharvest performance varied considerably among locations. Fruit stored for 6 months had the same fresh weight, less flesh firmness and higher SSC, than the 4 months storage. Later harvested fruit had greater fruit flesh firmness and higher SSC after storage. SSC after storage was predictable based on ripe soluble solids content (RSSC) at harvest. Summer pruning reduced while soil nitrogen application increased fruit SSC.

VOLATILE EMISSIONS FROM LETTUCE GROWN UNDER DIFFERENT TEMPERATURES, LIGHT INTENSITIES, AND PHOTOPERIODS

Graig S. Charron* and Daniel J. Cantliffe, Horticultural Sciences Dept., University of Florida, Gainesville, FL 32611

The National Aeronautics and Space Administration (NASA) is developing a Controlled Ecological Life Support System (CELSS) for long-term space exploration in which plants would be one major component. Volatile emissions from these plants may disrupt the proper functioning of CELSS. This research investigated how environmental factors alter the volatile emissions from hydroponically-grown 'Waldmann's Green' leaf lettuce. A growth chamber was modified to allow the injection of purified air into a glass enclosure positioned over individual lettuce plants. Air samples from the enclosure were analyzed by gas chromatography-mass spectrometry (GC-MS). The lipoxygenase pathway products (Z)-3-hexenal, (Z)-3-hexenol, and (Z)-3-hexenyl acetate were emitted following the end of the light period. Mechanical damage also stimulated the release of these same compounds. The design of toxin management systems in CELSS may need to incorporate these findings. Additionally, lipoxygenase pathway products have been previously demonstrated to influence insect behavior and pathogen growth, and may indicate future directions for plant breeding.

EFFECT OF PHOTOPERIOD ON NET CARBON ASSIMILATION AND PARTITIONING IN WHITE POTATO

G.W. Stutte*, N.C. Yorrio and R.M. Wheeler. The Bionetics Corp.(gws,ncy) and NASA Biomedical Operations and Research Office (rmw), Kennedy Space Ctr, FL 32899

Photoperiod treatments were imposed on potato (*Solanum tuberosum* L. cv. Norland) grown in the Biomass Production Chamber (BPC) at Kennedy Space Center under HPS lamps (670 $\mu\text{mol m}^{-2} \text{s}^{-1}$ PPF) at 1200 $\mu\text{mol mol}^{-1} \text{CO}_2$. Stand A_{max} decreased with dark cycle length, which correlated with the change in leaf starch concentration during the dark cycle, but not absolute starch concentration. A series of growth chamber experiments were performed to characterize the effect of photoperiod and PPF on CO_2 assimilation and starch mobilization in single leaves. Plants grown on a 12/12 photoperiod at either low (300 $\mu\text{mol m}^{-2} \text{s}^{-1}$) or high (600 $\mu\text{mol m}^{-2} \text{s}^{-1}$) PPF were subjected to short-term photoperiod treatments of 8/16, 16/8, and 24/0 and diurnal CO_2 assimilation rates, CO_2 response curves, and leaf starch content were determined. CO_2 compensation point was not affected by either photoperiod or PPF. However, A_{max} (when normalized for PPF) decreased with increasing photoperiod. A_{max} correlated with the changes in specific leaf weight and starch content during the dark cycle.

EFFECTS OF PLANT AGE AND CONSTANT NUTRIENT SUPPLY ON POTATO LEAF ELEMENTAL COMPOSITION

W.L. Berry*, R.M. Wheeler, C.L. Mackowiak, G.W. Stutte, and J.C. Sager, Biomed. and Envir. Sci. UCLA, Los Angeles, CA 90024 (wlb), NASA Biomed. Operations Office (rmw, jcs) and The Bionetics Corp. (clm, gws), Kennedy Space Center, FL 32899

Critical levels of nutrients in leaf tissue are influenced by plant metabolism, environment, and nutrient availability. In this study, we measured the elemental concentrations in fully expanded, upper canopy potato (*Solanum tuberosum* cv. Norland) leaves throughout growth and development in a controlled environment. Plants were grown hydroponically (NFT) in NASA's Biomass Production Chamber using a complete nutrient solution with the electrical conductivity maintained continuously at 0.12 S m^{-1} . Photoperiod and air and root zone temperatures were changed midseason to promote tuberization, while CO_2 levels were maintained at 1000 $\mu\text{mol mol}^{-1}$ throughout growth. During vegetative growth, leaf nutrient concentrations remained relatively constant, except for a decline in Ca. During tuber enlargement and plant maturation, overall nutrient uptake decreased. Concentrations of the less mobile nutrients such as Ca, Mg, and B increased in the leaf tissue during mature growth, but somewhat surprisingly, highly mobile K also increased. Leaf concentrations of P, Zn, and Cu decreased during maturation.

DEVELOPMENT OF A NEGATIVE WATER PRESSURE SYSTEM AND USE FOR CONTROLLING ASSIMILATE PARTITIONING IN POTATOES.

T.W. Tibbitts* and W. Cao, Univ. of Wisconsin, Madison, WI 53706

A nutrient delivery system developed for plant growth in space provides a unique system for maintaining a constant, slightly-negative water tension for plant research. The system involves the use of multiple porous stainless steel tubes positioned 4 cm apart in shallow trays (44 cm long, 32 cm wide and 8 cm deep), and then covered with a 4 cm layer of fine medium. Nutrient solution is recirculated through the porous tubes

117 ORAL SESSION 34 (Abstr. 241-246) Vegetables: In Life Support Systems

NUTRIENT MASS BALANCES AND RECOVERY STRATEGIES FOR GROWING PLANTS IN A CELSS.

C.L. Mackowiak*, R.M. Wheeler, W.L. Berry, and J.L. Garland, The Bionetics Corp. (clm, jlg), NASA Biomedical Operations Office (rmw), Kennedy Space Center, FL 32899, and UCLA, Laboratory of Biomedical and Environmental Sciences (wlb), Los Angeles, CA 90024-1786.

Wheat, soybean, potato, and lettuce crops were grown in a large (20 m^3), closed chamber to test plant production for life support in a Controlled Ecological Life Support System (CELSS). Plant crude protein levels were about 15% in wheat and potato biomass, 20% in soybean biomass, and 27% in lettuce biomass at harvest. Nitrate levels were not assayed, but likely contributed to the protein estimates. Nitric acid (used in hydroponic system pH control) contributed 43% for wheat nitrogen needs, 33% for soybean, 30% for potato, and 27% for lettuce. Lettuce contained the highest percent ash (22%) and wheat the lowest (10%). It was likely that the continuous nutrient supply in the hydroponic systems resulted in high ash values. The percentage of plant macronutrients in the inedible biomass was 7% in lettuce, 50% in soybean and potato, and 80% in wheat. Based on these values, perhaps 50% of the macronutrients needed in a multi-crop system could be removed from the inedible biomass and recycled back into the hydroponic system. Applicable technologies for nutrient recovery would include wet or dry oxidation (ashing), water soaking (leaching), or bioreactor degradation. The mass of reagent-grade salts needed in place of nutrient recycling could equal about 30% of the dry food mass required per person day⁻¹.

WATER, NUTRIENT, AND ACID REQUIREMENTS FOR CROPS GROWN HYDROPONICALLY IN A CELSS

R.M. Wheeler*, C.L. Mackowiak, W.L. Berry, G.W. Stutte, and J.C. Sager, NASA Biomed. Operations (rmw, jcs) and The Bionetics Corp. (clm, gws), Kennedy Space Center, FL 32899, and Biomed. and Environ. Sci., Univ. of Calif. (wlb), Los Angeles, CA 90024

Requirements for water, nutrient replenishment and acid (for pH control) were monitored for stands of wheat, soybean, potato, and lettuce grown in a recirculating hydroponic culture using a modified 1/2 Hoagland solution with $\text{NO}_3\text{-N}$. Water use at full canopy cover for all crops ranged from 4 to 5 $\text{L m}^{-2} \text{day}^{-1}$. When averaged over the entire crop cycle, nutrient stock solution ($\sim 0.9 \text{ S m}^{-1}$) use varied from 0.2 $\text{L m}^{-2} \text{day}^{-1}$ (lettuce) to 0.75 $\text{L m}^{-2} \text{day}^{-1}$ (wheat), while acid use varied from 6 $\text{mmol m}^{-2} \text{day}^{-1}$ (lettuce and soybeans) to over 40 $\text{mmol m}^{-2} \text{day}^{-1}$ (wheat). Water-per unit biomass was highest for soybean and lettuce (0.3 to 0.4 $\text{L g}^{-1} \text{DW}$), and least for wheat and potato (0.15 $\text{L g}^{-1} \text{DW}$). Nutrient replenishment per unit biomass was highest for lettuce, 34 $\text{mL g}^{-1} \text{DW}$, with other crops ranging from 21-26 $\text{mL g}^{-1} \text{DW}$. Acid requirements were highest for wheat, 1.2 $\text{mmol g}^{-1} \text{DW}$, and lowest for potato, 0.7 $\text{mmol g}^{-1} \text{DW}$. On a PAR basis, acid needs were highest for wheat, 0.6 mmol mol^{-1} photons, with all other crops near 0.4 mmol mol^{-1} . Acid data suggest that wheat nutrient uptake favors anions more strongly than the other species, or that more nitrate loss (e.g., denitrification) may occur during wheat growth.

under -5 cm (water head) of negative pressure maintained with a siphoning procedure. Potatoes grown with negative pressures were compared to growth in similarly constructed trays that were maintained on a slant and solution added to the upper end of the trays and drained from the lower end. The same nutrient solution was recirculated through the trays of each treatment and maintained at a pH of 5.6. A microcultured plantlet of Norland cv. was transplanted into each tray. The negative pressure produced plants with less total plant dry weight, leaf area, branches, and stolons but increased biomass partitioning into tubers. The data suggest that this small constant negative water pressure regulates assimilate partitioning to encourage production of tubers.

118 ORAL SESSION 35 (Abstr. 247-253) Vegetables: Cell and Tissue Culture

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SOMATIC HYBRIDIZATION BETWEEN *SOLANUM OCHRANTHUM* AND *LYCOPERSICON ESCULENTUM*

Ruth S. Kobayashi*, Stephen L. Sinden and John R. Stommel
USDA/ARS, Vegetable Laboratory, Bldg. 011, H.H. 13, BARC-West, Beltsville MD 20705

Incorporation of genes from wild species has been a major contributor to tomato improvement in recent years. *Solanum ochranthum*, a woody non-tuber bearing species, is a potential source of resistance against tomato diseases and insect pests but is genetically isolated from tomato. Somatic hybridization methods were developed to facilitate the use of *S. ochranthum* for tomato germplasm improvement. Leaf mesophyll protoplasts of *S. ochranthum* and a *Lycopersicon esculentum* hybrid were chemically fused with polyethylene glycol. The protoplasts were initially cultured in Shepard's CL, a MS based medium, containing 1 mg·l⁻¹ NAA, 0.5 mg·l⁻¹ BAP and 0.5 mg·l⁻¹ 2,4-D. Hybrid regenerants and regenerants of the *L. esculentum* parent were recovered; *S. ochranthum* did not regenerate. Hybridity was established by morphological characters, peroxidase isozyme and RAPD markers. Use of these somatic hybrids for tomato improvement was evaluated.

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COMPARISON OF MEDIUM, TISSUE TYPE AND GENOTYPE ON IN VITRO PLANT REGENERATION OF TOMATO

Roger L. Vallejo* and Jane E. Polston, University of Florida, Gulf Coast Research and Education Center, 5007 60th St. East, Bradenton, FL 34203

Cultured cotyledon and leaf pieces of five cultivars of *Lycopersicon esculentum* Mill. were tested in six culture media for their ability to produce shoots for transformation studies. The no. of tissue pieces with callus/total tissue pieces, quality of callus (size and vigor), no. of tissue pieces with shoots/total tissue pieces, and shoot quality (size and vigor) were measured. Cultivars tested were 'Campbell 28', 'Flora-Dade', 'UC82b', and two breeding lines, Fla.7171 and Fla.7324. The six media used were Murashige and Skoog medium supplemented with six combinations of indole acetic acid (IAA) and cytokinins: A) 1 mg/l IAA + 1 mg/l kinetin, B) 0.5 mg/l IAA + 2 mg/l kinetin, C) 0.02 mg/l IAA + 1 mg/l zeatin, D) 0.2 mg/l IAA + 2 mg/l zeatin, E) 1 mg/l IAA + 2.5 mg/l BAP (6-benzyl amino purine), and F) 0.2 mg/l IAA + 1 mg/l BAP. Standard procedures were followed for culturing 4 - 5 mm pieces of cotyledon and leaves. Callus and shoot regeneration were greater, less variable and faster, in cotyledon than in leaf pieces. Media C and F gave the highest rates of callus and shoot production, respectively, in cotyledon tissue. Medium E gave the highest rate for both callus and shoot production in leaf discs. The best rates of shoot production were achieved with cotyledon tissue from cultivar UC82b cultured on media C (85.3%) and F (77.2%).

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REGENERATION OF GARLIC, *Allium sativum* L., AND ITS IMPLICATION FOR TRANSFORMATION

J. Michele Myers* and Philipp W. Simon, USDA-ARS, Vegetable Crops Research., Department of Horticulture, University of Wisconsin-Madison, Madison, WI 53706

Garlic callus derived from young basal plate explants of one genotype was evaluated for regeneration. Callus was initiated on a modified B5 medium supplemented with 2,4-D for 10 weeks and then subcultured on medium with picloram + 2iP for 10 weeks. This friable

callus was used in regenerating plants. Callus was transferred to a modified B5 medium with 10 hormonal combinations of auxins and cytokinins in a complete factorial design. Four pieces of callus about 1.0 cm square were transferred to a petri plate with four replications per treatment. Callus was subcultured monthly to ensure optimum growth and data was collected after three months in culture. The best regeneration frequency occurred on medium supplemented with picloram + BA. Regenerated lines were then transferred to medium with no hormones for evaluation of single plants. The genetic stability of these regenerated lines was tested using polyacrylamide gel electrophoresis (PAGE) and six isozyme systems. This regeneration system will be very useful in the production of regenerated putative transformed lines from callus.

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INDUCTION AND AVOIDANCE OF VITRIFICATION OF MICROPROPAGATED ONION (*ALLIUM CEPA* L.)

Renee M. Schloupt, Walter E. Splittstoesser, and Robert M. Skirvin, University of Illinois, Department of Horticulture, 1102 S. Goodwin Ave., Urbana, IL. 61801

The objective of this research was to induce vitrification in onion (*Allium cepa* L. cv. 'White Ebenezer'); then use this information to make suggestions on how to avoid vitrification of micropropagated plants. There were no differences in vitrification percentage when shoot tip explants were isolated, sterilized and placed on MS medium (8 g·l⁻¹ agar) supplemented with 0.16 uM NAA and varying (0.0 to 70.0 uM) levels of BA. When agar was replaced by gelrite (MS medium with 4.4 uM BA and 0.16 uM NAA), vitrification increased when gelrite concentrations decreased from 2.0 to 1.0 g·L⁻¹. More vitrification occurred when shoot tips were supported on a synthetic cosmetic puff in liquid medium or when agar was reduced to 4.0 g·L⁻¹ than when supported on a cosmetic puff in 8 g·L⁻¹ agar or on 8 g·L⁻¹ agar alone.

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CARBON DIOXIDE ENRICHMENT AND CARBOHYDRATES IN ANDROGENESIS OF CAPSICUM ANNUUM L.

Ramon Dolcet-Sanjuan* and Elisabet Claveria, Departament de Genètica Vegetal, IRTA, Ctra de Cabriels s/n, 08348 Cabriels (Barcelona), Spain

Anthers from more than 17000 flowers of 19 bell pepper *Capsicum annuum* L. hybrids (provided by 'Semillas Fitó S.A.') were cultured in a double layer modified H medium (Nitsch and Nitsch, 1969) supplemented with 0.5 % activated charcoal and 0.26 % Gelrite in the solid phase. Significant differences between genotypes were observed on embryogenesis (472.3 to 9.7 embryos / 100 flowers) and number of plants rescued (4.0 to 0.3 plants / 100 flowers). Trying out maltose, malt extract, and sucrose as carbohydrates, at 20, 40, 60 or 80 g/l, gave significantly better results for maltose (20 or 40 g/l). In addition, maintaining the anther cultures in an atmosphere enriched with 600 ppm CO₂ was beneficial for embryo number, embryo development and number of rescued plants. Isocitrate dehydrogenase zymograms from leaf extracts indicate the microspore origin of the acclimated plants. Flow cytometry of nuclei was used to determine an early diploidization of 70 % of the acclimated plants.

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STUDIES ON ADVENTITIOUS REGENERATION IN COCOYAM

Leopold M. Nyochembeng and Stephen Garton, Department of Plant and Soil Science, Alabama A & M University, P.O. Box 1208, Normal, AL 35762.

Studies were conducted to determine the response of cocoyam shoot tips, petioles, cotyledons and hypocotyls in various media for callus formation, adventitious shoot development and somatic embryogenesis. In all experiments, B5 basal medium or low N B5 were supplemented with various growth regulators.

High frequency adventitious shoot proliferation was obtained using cotyledons and hypocotyls in medium supplemented with 1 mg/l IBA and 0.5 mg/l TDZ. Embryogenic callus was obtained using shoot tips in media containing 1 mg/l Dicamba, while somatic embryos were observed in media containing 0.3 mg/l 2,4-D and 1 mg/l Kinetin, using hypocotyl and petiole explants. The impact of these results on micropropagation of cocoyam is discussed.

MICROPROPAGATION, A MEANS TO ENHANCE SWEETPOTATO YIELD AND QUALITY

Jonathan R. Schultheis*, Wanda W. Collins, and Charles W. Averre
Horticultural Science, North Carolina State Univ., Raleigh, NC 27695-7609 and Plant Pathology, North Carolina State Univ., Raleigh, NC 27695-7616

Micropropagated sweetpotato is utilized in California as pan of its seed production program. Sweetpotato yields and quality might be improved in North Carolina by incorporating micropropagation as pan of its plant production scheme. Field studies were conducted in 1992 and 1993 to determine the effects of micropropagation, virus, and hill selection on yield and quality of Jewel and Beauregard varieties. In 1992, yield was increased in Beauregard with micropropagated plants compared with plants that were derived from the North Carolina seed program. However, no yield advantage was measured when Jewel was micropropagated. In 1993, yield from micropropagated Beauregard sweetpotato plants was the same as when plant material was derived from the North Carolina Certified Seed program. Virus-free micropropagated Beauregard plants yielded more number one and canner grade roots than micropropagated plants that harbored the virus at planting. Russet crack symptoms were significantly greater in roots that were not micropropagated compared with micropropagated plants. Total marketable yield of Jewel was increased when obtained from micropropagated versus nonmicropropagated plant stock. Micropropagated Jewel obtained from a California selection yielded nearly 20% less than the North Carolina selection. Yields from micropropagated planting stocks consistently were equal to or better (typically 10 to 20%) than from plant stock not micropropagated.

119 ORAL SESSION 36 (Abstr. 254-259) Floriculture: Nutrition

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KJELDAHL N:DUMAS N RATIOS FOR SELECTED CROPS

E.H. Simonne¹, J.N. McCrimmon^{2*}, H.L. Scoggins-Mantero³, and H.A. Mills³, ¹Department of Horticulture, Auburn University, Auburn, AL 36849, ²Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, NM 88003, ³Department of Horticulture, University of Georgia, Athens, GA 30602-7273

With recent advances in N analyzers, the Dumas method becomes more attractive as a replacement for Kjeldahl N. Kjeldahl N (K_N):Dumas N (D_N) ratios were determined for anthurium (A), orchid (O), fern (F) and turf (T). Dry tissues were ground to pass a 20-mesh sieve. D_N was determined using 0.2 g of sample and a Leco FP-428. K_N was determined by digesting 0.4 g tissue with a $CuO/TiO/K_2SO_4$ catalyst and 10 mL H_2SO_4 at 450°C for 2 hr. Ammonium in the digest was assayed by colorimetry (Lachat analyzer). Overall (n=397 obs.), D_N was a good estimator of K_N : $K_N = 0.90$ ($p<0.01$) $D_N + 0.09$ ($p<0.01$), $R^2=0.93$, over the 0.4-6.6 N range. $K_N:D_N$ ratio was significantly ($p<0.01$) affected by plant type. Ratios of 0.85 for A, 0.92 for T, 0.99 for O, and 1.00 for F may be used to estimate K-N from D-N for the diagnosis of N nutrition, along with existing interpretative data.

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LEACHING FRACTION, FERTIGATION RATE AND PHOSPHORUS LEACHING FROM POTTED GERANIUM

Catherine S.M. Ku*, Department of Horticulture, University of Maryland, College Park, MD 20742-5611

David R. Hershey, Department of Botany/Horticulture, Prince George's Community College, 301 Largo Road, Largo, MD 20772-2199

Single-pinched 'Yours Truly' geranium (*Pelargonium x hortorum*) were greenhouse grown in 15-cm diameter pots. They received constant liquid fertigation with a modified Hoagland solution #1 at 0.25, 0.5, 1.0, and 1.5 strength. The 1.0 strength Hoagland solution contained 210 mg/L NO_3^- -N and 31 mg/L P. Leaching fractions (LFs) were 0, 0.2 and 0.4. The total P applied via fertigation ranged from 33 mg at 0 LF and 0.25x Hoagland to 407 mg at 0.4 LF and 1.5x Hoagland. The leachate P concentration ranged from <5 mg/L to -60 mg/L. The P concentration in the recently matured leaves was in the acceptable range for all treatments. We were able to recover 90 to 99% of the applied P by analyzing the shoots, soilless medium, and leachate. Only 4% of the recovered P was in the leachate for plants receiving 0.5x Hoagland and a 0.2 LF. However, these plants were equal in yield to plants receiving higher fertigation rates and higher LFs.

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THE EFFECT OF VARYING THE N:S BALANCE IN POINSETTIA ON PLANT COLOR RESPONSE AND CONSUMER APPEAL

Stacy A. Adams* and Ellen T. Paparozzi, Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724.

Nitrogen and sulfur are macronutrients required by plants to form amino acids used in protein synthesis and other metabolic processes. Commercial poinsettia nutrient recommendations suggest N levels of 350-400 ppm later reduced to 200-250 ppm N. Previous hydroponic research determined that N may be reduced by half if supplied S levels are adequate. The purpose of this study was to look at multiple N and S levels and gauge the effects these combinations had on plant quality.

Poinsettia cv. 'Dark Red Hegg' plants, grown in a soilless mix, were fertilized with 56 N and S combinations. N was supplied from 100-275 ppm and S from 0-75 ppm. Plants were evaluated quantitatively by chroma meter readings every three weeks and qualitatively by marketability evaluations from commercial producers, retailers, and consumers.

Results indicate 0 ppm S plant color was more yellow-green than all others. Plants were greener as N increased from 100-150 ppm with no difference above 175 ppm. Evaluators identified plants receiving 0 ppm S and 100 or 125 ppm N as unmarketable. N may be reduced to 175 ppm with no effect on plant quality if adequate S is applied.

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LEAF PETIOLE NITRATE AND POTASSIUM LEVELS IN POTTED PLANTS GROWN AT THREE NITROGEN AND POTASSIUM LEVELS

Erica M. Bergman, Michelle Marshal, Brian Weesies, Bill Argo and John Biernbaum*, Michigan State University, Department of Horticulture, East Lansing, MI 48824-1354

Twelve species of flowering potted plants were grown in a peat-based medium with water soluble fertilizer concentrations of 50, 100, or 200 mg-liter⁻¹ N and K_2O . Leaf blade or leaf petiole samples were collected six to eight weeks after planting. Sap was expressed using a hydraulic press and levels of nitrate nitrogen and potassium were determined using Cardy flat sensor ion meters. Petiole nitrate level ranged from 520 to 6300 mg-liter⁻¹ and potassium levels ranged from 870 to 3600 mg-liter⁻¹. The petiole nitrate concentration and change in petiole nitrate levels with changes in media nitrate levels was crop dependent. Leaf blade nitrate and potassium concentrations were lower than leaf petiole concentrations. The relationship of petiole nitrate to final plant fresh and dry mass and appearance at flowering will be presented.

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AVAILABILITY AND PERSISTENCE OF MACRONUTRIENTS FROM PREPLANT NUTRIENT CHARGE MATERIALS AND LIME IN PEAT-BASED ROOT MEDIA

William R. Argo* and John A. Biernbaum, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

Four experiments were conducted with six liming materials of different particle sizes and six commercially available blended preplant nutrient charge (PNC) materials in the laboratory and in container culture with subirrigation for durations up to twenty-eight days. Liming material, particle size, and incorporation rate affected both the initial and final stable pH of one type of peat without an incorporated PNC. Saturated media extract (SME) Ca^{2+} and Mg^{2+} concentrations were below the acceptable recommended concentrations for both pulverized and superfine dolomitic lime at incorporation rates up to 7.2 kg-m⁻³. For the blended PNC materials, initial N, P, K⁺, Ca^{2+} , and Mg^{2+} concentrations for five of the six PNC materials were at or above the optimal concentrations recommended for an SME, but did not remain persistent in the root zone. A large percentage of all nutrients tested moved from the root zone into the top 3 cm (top layer) of the pot within two days after planting. Nutrient concentrations in the top layer continued to increase even when nutrient concentrations in the root zone fell below acceptable levels for an SME. The importance of this fertilizer salt stratification within the pot lies in the reduced availability of nutrients to the plant.

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NITROGEN RATE/SOURCE/TIMING EFFECT ON CHRYSANTHEMUM ROOT CHEMISTRY AND FUNCTION IN POSTHARVEST

Stephen A. Carver*, Michael Knee, Harry K. Tayama, Dept. of Horticulture, The Ohio State University, 2001 Fyffe Ct., Columbus, OH 43210

Dendranthema grandiflora 'Spirit' and 'Iridon' were grown in a 2-factor experimental design consisting of 3 nitrogen rate/source treatments (100 mg/liter N (25% NH_4^+), 400 mg/liter N (25% NH_4^+), and 400 mg/liter N { 5% NH_4^+ }), and 2 fertilizer termination treatments (bud-color and harvest)

Evaluation of various production characteristics including plant and flower size, days to flower, leaf number and size, and leaf, shoot, flower and root fresh/dry weight, revealed few significant differences among treatments. High foliar N content in all treatments (ranging from 6.1 to 8.5%) may provide an explanation for the apparent lack of differential treatment production response. However, there were significant treatment differences in floral and foliar postharvest keeping quality. High NH_4^+ grown plants declined 1-2 weeks sooner than other treatments, and plants fertilized to harvest declined 0.5-1 week sooner than those fertilized to bud color. Root fresh and dry weights measured 2 weeks into postproduction disclosed significant differences between treatments that mirrored foliar and floral longevity. Results of a satellite study in which root and stem hydraulic conductivity, root total soluble carbohydrates, starch, and protein content, and water loss rate during postharvest will be presented.

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NITROGEN PARTITIONING IN APPLE IS AFFECTED BY TIMING AND TREE GROWTH HABIT

Habib Khemira*, Timothy L. Righetti, Anita N. Azarenko. Dept. of Horticulture. Oregon St. Univ., Ag & Life Sci., Corvallis, OR 97331.

Young bearing spur (Red-Spur Delicious) and standard (Top-Red Delicious) type apple trees were given one of the following treatments: 120g N applied to the ground in spring (SG), 120g N applied to the ground one month before harvest (PG), 60g N sprayed on the foliage after harvest (FF), 60g N SG and 60g N PG, or 60g N SG and 60g N FE Urea and NH_4NO_3 depleted in ^{15}N (0.01 atom percentage ^{15}N) were used for foliar and ground applications, respectively. Very little labeled N was present in leaves and fruit with PG applications, but roots, bark, and buds contained substantial amounts of it. Nitrogen from the FF sprays was effectively translocated to buds and bark. Percentage of N from the fertilizer in Sept leaves from spur-type trees that had only 60 g of N in spring was 56% higher than that found in standard-type trees. This figure rose to 180% with 120 g N spring application. Mature fruit showed the same trend. Spur-type trees appeared more responsive to N management practices. In contrast to the above ground structure, small roots of standard-type trees showed more label than those of spur-type trees. The difference was bigger with SG applications. Partitioning of N in the roots was apparently affected by the scion.

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ALTERNATIVE SOURCES FOR FOLIAR APPLICATION OF POTASSIUM TO APPLE TREES

Warren C. Stiles*, Department of Fruit and Vegetable Science, Cornell University, Ithaca, NY 14853-0327

Potassium nitrate, potassium sulfate and potassium acetate were applied as foliar sprays at recommended rates for each material to Empire and McIntosh apple trees in a potassium deficient orchard. Five sprays of each material were applied at approximately one-week intervals beginning in mid-August. All sprays were applied by means of a small air-blast sprayer calibrated to deliver 800 l ha⁻¹ of a 1.744X tank mix, i.e. equivalent to dilute sprays of 1400 l ha⁻¹. Total amounts of K applied per ha were 8.6 kg with K-acetate and 28 kg ha⁻¹ with K-nitrate and K-sulfate. Leaf samples were collected from each plot at normal harvest date for each variety and washed prior to drying and analysis. Regression analysis indicated a significant ($P=0.05$) positive relationship, $r = +0.4740$, between total amount of K applied and leaf K regardless of the source. Significant positive relationships were found between average fruit weight and percent leaf potassium with both varieties.

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FERTIGATION VERSUS DRY APPLICATION OF NITROGEN AND PHOSPHORUS FERTILIZER IN IRRIGATED 'GALA' AND 'FUJI' APPLES

Frank J. Peryea, Washington State University, 1100 N. Western Ave., Wenatchee, WA 98801

Differential fertilizer application method (single dry, split dry, fertigated liquid), irrigation method (drip, microjet), and nutrient source (N vs. N+P in year 2+) were established in Spring 1992 in a newly planted Gala and Fuji apple orchard. In Spring 1993, the drip-fertigated Gala trees had 3 times and the drip-fertigated

Fuji trees had 8 times more flower clusters per tree than the other treatments. Fruiting was not allowed in 1993. Trunk cross-sectional area (TCSA) in Fall 1992 was not influenced by treatments. By Fall 1993, TCSA was still independent of treatment for the Fuji trees; however, the Gala trees fell into two size groups - (larger) microsprinkler-fertigated and split dry broadcast; and (smaller) drip fertigated and single-time spring dry broadcast. TCSA had increased 284% (Fuji) and 265% (Gala) since planting. None of the treatment effects were substantially influenced by fertigating with N+P vs N only. Leaf concentrations of most nutrients were consistently lower in 1993 than in 1992. Leaf Fe was higher in 1993 because the orchard was dustier. Leaf N was lower in the microsprinkler-fertigated trees than in all other treatments. Fertigation with N+P did not consistently produce higher leaf P than the N-only treatments. Leaf Mn varied with treatment: microsprinkler fertigated < drip fertigated, single dry < split dry. Treatment effects on all other elements were inconsistent (K, Ca, Mg, B, Cu) or absent (Zn, Fe).

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RESPONSE OF SOIL SOLUTION $\text{NO}_3\text{-N}$ TO N FERTIGATION

Gerry H. Neilsen*, Denise Neilsen, Peter Parchomchuk and Eugene Hogue, Agriculture Canada, Research Station, Summerland, BC V0H 1Z0

Soil solution monitoring has been suggested as an appropriate procedure to optimize fertigation timing and application rate. Soil solution $\text{NO}_3\text{-N}$ concentrations were measured for two growing seasons on a sandy loam soil when 5, 20 or 30 g N per season per tree were fertigated daily to apples as calcium nitrate from mid May-mid July. Soil solution $\text{NO}_3\text{-N}$ concentrations at 30 cm depth changed rapidly in response to both the initiation and cessation of fertigation, with values ranging from 10-20 ppm, 60-100 ppm and 100-200 ppm for the low to high treatments respectively. The rapid response to $\text{NO}_3\text{-N}$ fertilizers implied a potential to control closely the timing of N fertilizer applications. In another experiment, 'Empire' apple trees were fertigated 5 times/week from May 31 to August 9 with 30 g N/tree applied either as ammonium sulphate or as calcium nitrate. With calcium nitrate as the N source, $\text{NO}_3\text{-N}$ rapidly increased when fertigation was initiated and fell when fertigation ended. In contrast, with ammonium sulphate, $\text{NO}_3\text{-N}$ was low for about 30 days after initiation of fertigation, then increased to 100 ppm and remained elevated for 40-50 days after fertigation ended. The potential control of N nutrition appeared to be less exact when fertigating $\text{NH}_4\text{-N}$.

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UPTAKE OF FOLIAR UREA BY PEACH LEAVES

R. Scott Johnson*, Harry Andris and Shanti Handley, Department of Pomology, University of California Kearney Agricultural Center, 9240 S. Riverbend Avenue, Parlier, CA 93648

Foliar urea sprays offer an alternative to soil applied fertilizers which could greatly reduce the potential for nitrate pollution of groundwater. The approach in the past has been to apply relatively small doses of urea in order to minimize leaf phytotoxicity. Our approach is to apply relatively large doses in the fall when leaf phytotoxicity is not a serious concern. Results on peach trees in the field indicated rapid uptake of foliar applied solutions of 4.3 to 8.8% urea (w/w) (2.0 to 4.0% N). About 80-90% of the urea was absorbed by the leaf within 24 hours. Leaf N levels suggest the majority of this urea was translocated from the leaf into the tree within 1 week despite damage to the leaf. There were no negative effects on flowering, fruit set and production in the following year as long as a very low biuret formulation of urea was used.

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SPRING NITROGEN UPTAKE, ALLOCATION, AND LEACHING LOSS OF CITRUS IN A SANDY SOIL.

John D. Lea-Cox* and James P. Syvertsen.

University of Florida, IFAS, Citrus Research and Education Center, 700 Experiment Station Rd., LAKE ALFRED, FL 33850.

Eighteen, 4-year-old Grapefruit (*Citrus paradisi*) cv. 'Redblush' trees on either Volkamer lemon (*C. volkameriana* = VL) or Sour orange (*C. aurantium* = SO) rootstocks were grown in 7.6 kiloliter drainage lysimeters in a Candler fine sand (Typic Quartzipsamments), and fertilized with nitrogen (N) in 40 split applications at 76, 140 and 336 g N year⁻¹ (= 0.2, 0.4 and 0.9 x the recommended annual rate). Labelled ^{15}N was substituted for the N in a single fertigation at each rate at the time of fruit set the following year, to determine N uptake, allocation and leaching losses. "Nitrogen-uptake and allocation were primarily determined by the sink demand of fruit and vegetative growth, which in turn were strongly influenced by rootstock species. Larger trees on VL required at least 336 g N yr⁻¹ to maintain high growth rates whereas smaller trees on SO of the same age only required 140 g N year⁻¹. Of the ^{15}N applied at the 336 g N rate to the SO trees, 39% still remained in the soil profile after

29 days. With optimally scheduled irrigations, ^{15}N leached below the root zone was less than 3% of that applied after 29 days, regardless of rate. However, 17% of the applied ^{15}N was recovered from a blank (no tree) lysimeter tank. Total ^{15}N recovery ranged from 55-84% of that applied, indicating that a sizeable fraction of the ^{15}N applied may have been lost through denitrification.

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NITROGEN EFFECT ON GROWTH OF YOUNG 'HAMLIN' ORANGE/'SWINGLE' CITRUMELO TREES IN THE NURSERY

L. Guazzelli, F.S. Davies* and J.J. Ferguson, Horticultural Sciences Department, Univ. of Florida, Gainesville, FL 32611

Two experiments were conducted with containerized 'Hamlin' orange trees (*Citrus sinensis* [L.] Osb.) on 'Swingle' citrumelo (*C. paradisi* Macf. x *Poncirus trifoliata* [L.] Raf.) rootstock to study the effects of N rate on growth of plants in the nursery. Treatments consisted of the following N rates: 12, 50, 100 and 200 mg-liter⁻¹ applied once a week through drip irrigation. In Expt. 1, fertilization at the 200 mg-liter⁻¹ rate resulted in greater scion growth, trunk diameter and total leaf dry weight as compared to the other rates. In Expt. 2, application of 100 and 200 mg-liter⁻¹ rates resulted in greater scion growth and trunk diameter as compared to lower rates, but no differences were seen between the two highest rates. Trees receiving the 12 and 50 mg-liter⁻¹ rates were stunted and leaves were chlorotic. Therefore, the optimum N rate for trees on 'Swingle' citrumelo rootstock is between 100 and 200 mg-liter⁻¹, although the 200 mg-liter⁻¹ rate may not be economically justified. Moreover, the N rate for nursery plants growing on 'Swingle' citrumelo rootstock in commercial medium may be higher than for other rootstocks, where rates less than 50 mg-liter⁻¹ produce optimum growth.

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RECLAIMED WATER EFFECTS ON LEAF, SOIL AND SOIL SOLUTION NUTRIENT LEVELS OF GRAPEFRUIT.

M.A. Maurer*, F.S. Davies & D.A. Graetz, Univ. of Florida, Horticultural Sciences Dept., Soil Science Dept., Gainesville, FL 32611

A field study was conducted on mature 'Redblush' grapefruit trees (*Citrus paradisi* Macf.) on sour orange (*Citrus aurantium* L.) rootstock from 1991 to 1993 near Vero Beach, Fla. on poorly drained (flatwoods) soil to determine the effects of reclaimed water on leaf, soil and shallow well-water nutrients. Treatments consisted of a canal water applied based on soil moisture depletion, and reclaimed water applied at 23.1, 30.7 and 36.6 mm/wk. Reclaimed water treatments received supplemental fertilization in addition to the N present in the water. All treatments received about 130 kg/ha/yr N. Leaf tissue N, P, K, Ca, Mg and Na concentrations were similar for all treatments, but B concentrations were significantly higher for the reclaimed water treatments in 1991 and 1993. Soil P and Na concentrations also increased in the reclaimed water treatments. Water samples taken from shallow depth wells showed that reclaimed water treatments had lower levels of NO₃⁻ compared to the control possibly due to leaching. Reclaimed water contained only trace or undetectable levels of heavy metals.

in the orchards under higher humidity during the maturing season. Also the factors, such as higher humidity and lower temperature in storage room increase the dark browning. Dark browning is a different physiological disorder with the superficial scald of apples, which associated with conjugated trienes, oxidation products of alpha-farnesenes. The dark browning was controlled by dipping the harvested pears into 1,000 ppm diphenylamine (DPA) solution for 5 seconds before storage.

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CELL WALL CHANGES IN RIPENING NASHI (HOSUI) FRUIT

L.D. Melton and L.M. Davies, Department of Consumer Sciences, University of Otago, Dunedin, New Zealand.

Cell wall changes during ripening have a major effect on fruit texture. The cell walls isolated using phenol-Tris buffer were sequentially extracted to give polysaccharide fractions that contained mainly water-soluble pectin, chelator-soluble (CDTA) pectin, hemicelluloses (0.05 M Na₂CO₃ followed by 1M and 4M KOH) and cellulose. The fractions were analyzed colorimetrically for uronic acid, total neutral sugar and cellulose contents. The component sugars of each fraction were determined as their alditol acetates by GC. Then was a decrease in the two pectin fractions during ripening. The pectins appear to have arabinan and galactan side chains. Pectic galactose decreases during ripening. The weight of the combined hemicellulose fractions did not change during ripening, nor did the cellulose level. At least two types of arabinan are present. Pectins were found in all cell wall fractions. Nashi cell walls contain a relatively large amount of xylan compared to other fruit.

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EFFECTS OF INTERMITTENT WARMING ON CELL WALLS OF NECTARINES

D.M. Dawson^{1,2}, L.D. Melton¹ and C.B. Watkins², ¹University of Otago, P.O. Box 56, Dunedin, and ²The Horticulture and Food Research Institute of New Zealand, Private Bag 92 169, Auckland, New Zealand.

Nectarine fruit (*Prunus persica* (L.) Batsch) cv. Fantasia, were ripened immediately after harvest (normal ripening), or stored for 6 weeks either continuously at 0°C or were intermittently warmed (IW) for 48 h at 20°C after 2 and 4 weeks, and then ripened. Fruit subjected to IW ripened normally, whereas the continuously stored fruit developed mealiness during ripening. Normal ripening was associated with solubilization and depolymerization of pectic polymers and a net loss of galactose. Only limited pectic solubilization and removal of side chains occurred during ripening of mealy fruit. Pectic polymer polymerization occurred at each IW occasion continued during ripening after storage, but was not as extensive as in normally ripened fruit. Mealy fruit had high autolytic capacity, probably as a result of insoluble pectic polymers in the cell wall that were not solubilized during ripening. The release of uronic acid suggests that cool storage temperatures do not irreversibly inhibit polygalacturonase activity.

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EXPRESSION OF NADP-MALIC ENZYME RNA LEVELS IN RIPENING PEACH FRUIT

Ann M. Callahan and Carole L. Bassett*, USDA, ARS, Appalachian Fruit Research Station, 45 Wiltshire Rd., Kearneysville, WV 25430

NADP-dependent Malic Enzyme (NADP-ME, EC 1.1.1.40) catalyzes the decarboxylation of malate, resulting in the release of CO₂. In C3 plants the enzyme does not contribute CO₂ directly to photosynthesis. Rather, it is associated with the supplemental synthesis of glycolytic and Krebs Cycle intermediates, although it may also be involved in regulating intracellular pH. NADP-ME activity increases during ripening of several fruits e.g. tomato and apple, usually in association with increased respiration of the developing fruit. We examined expression of NADP-ME during ripening in peach using a cDNA probe derived from *F. trinitaria* (C4 dicot). The probe hybridized to a single RNA species of the predicted size and was low in abundance as expected for a C3 NADP-ME. As fruit matured, the RNA levels increased to a maximum around 133-140 days after bloom (fully ripe). NADP-ME RNA was not detectable from leaves isolated at the same time.

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DARK BROWNING AND ITS CONTROL OF 'NIITAKA' JAPANESE PEARS DURING STORAGE

Wol Soo Kim*, Seong Bong Kim, Nam Hyun Song and Han Chan Lee. Dept. of Fruit Cultivation, Fruit Tree Research Institute, Rural Development Administration, 475 Imok-dong, Jangan-ku, Suwon, KOREA

Dark browning of fruit skin of Japanese pear 'Niitaka' (*Pyrus pyrifolia*) is a physiological disorder during storage. Very higher rates of dark browning were observed in bagged pears, and

CONTROL OF BROWN ROT OF PEACHES AND APRICOTS WITH HOT WATER AND CONTROLLED-ATMOSPHERE STORAGE

Salah E. Youssef* and Elizabeth J. Mitcham, Plant Pathology Research. Inst., ARC, Giza, Egypt and Dept. of Pomology, Univ. of CA, Davis, CA 95616

Peaches and apricots were obtained at harvest. One-half were inoculated with the brown rot organism (*Monilinia fructicola*) and incubated overnight before immersion in 52C water for 2.5 and 2 minutes, respectively. Fruit were placed in storage at SC in air, 2% O₂ and 15% CO₂, or 17% O₂ and 15% CO₂ for 5 or 15 days before ripening at 20C. For peach, controlled atmosphere (CA) had no influence on decay while hot water significantly reduced decay incidence and severity. For apricot, after 15 days cold storage, both hot water and controlled atmosphere storage reduced decay incidence and severity. CA with 2% O₂ and 15% CO₂ controlled decay better than 17% O₂ and 15% CO₂. Growth and sporulation of *Monilinia fructicola* in air and CA was also evaluated in vitro. The combination of heat and CA controlled decay better than either treatment alone. The hot water treatment resulted in minor surface injury on peaches while apricots were not injured. Fruit were evaluated after storage for firmness, soluble solids, and titratable acidity. Accumulation of ethanol and acetaldehyde as a result of CA storage was monitored.

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PRODUCTION OF VOLATILE COMPOUNDS BY 'BING' SWEET CHERRIES AFTER CONTROLLED-ATMOSPHERE STORAGE.

James Mattheis*, David Buchanan, USDA, ARS, 1104 N. Western Ave., Wenatchee, WA. 98801, Nathan Reed, Stemilt Growers, Olds Station Rd., Wenatchee, WA. 98801, John Fellman, Dept. Plant, Soil, Entomological Sciences, University of Idaho, Moscow, ID. 83843. Sweet cherry ripening is slowed during low oxygen and/or high carbon dioxide controlled atmosphere storage. Cherry flavor can be impacted by prolonged CA storage, therefore ripening after CA and storage was evaluated including production of fruit volatile compounds. 'Bing' sweet cherries were harvested at commercial maturity and stored for up to 12 weeks at 1C in air or 5% O₂, with 0.1, 10, 15 or 20% CO₂. Fruit quality and condition were evaluated after removal from storage plus 1 or 4 days at 20C. Changes in fruit color were slowed by all atmosphere treatments with differences most notable after longer storage durations. Volatile synthesis changed as storage duration increased, however, treatment differences were not significant. Soluble solids content was maintained at 15 and 20% CO₂, but treatment differences were significant only after longer storage durations. High CO₂ treatments were effective at reducing decay incidence, but residual suppression after removal from storage decreased as storage duration increased. Significant treatment effects were evident for titratable acidity retention after 8 and 12 weeks storage, however, titratable acidity significantly declined in all treatments compared to the initial concentration.

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EFFECTS OF STORAGE TEMPERATURE, KERNEL INTACTNESS, AND ROASTING TEMPERATURE ON VITAMIN E, FATTY ACIDS AND PEROXIDE VALUE OF HAZELNUTS.

Kais S. Ebrahem*, Daryl G. Richardson, and Richard M. Tetley, Department of Horticulture, Oregon State University, Corvallis, OR, 97331.

Kernels in the shell were compared to bare kernels with pellicles, half nuts, blanched nuts, finely chopped nuts, and roasted nuts. Whole nuts and whole kernels were stable for up to two years of storage provided they had not been exposed to high temperatures. Nuts stored at low temperatures (0 and 5°C) did not lose significant amounts of vitamin E. Increasing surface area by dividing nuts or finely chopping them, increased the loss of vitamin E. Samples that had lower surface areas did not lose much vitamin E and peroxide value was low. Higher roasting temperatures caused losses in vitamin E and increased peroxide values at the beginning and during storage, even when stored at 0°C. Intact nuts and low storage temperatures did not show changes in fatty acid composition. High temperature treatments changed fatty acid composition, mainly decreasing linoleic initially and finally oleic acids.

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VAPOR PHASE HYDROGEN PEROXIDE TREATMENT OF WALNUT NUTMEATS (*Juglans regia* L.) FOR CONTROL OF MICROORGANISMS

Gilbert F. Simmons*, Joseph L. Smilanick, Nuria Denis-Arrue, Dennis A. Margosan and Shama John, USDA, ARS, Horticultural Crops Research Laboratory, 2021 South Peach Avenue, Fresno, CA 93727

A new vapor phase hydrogen peroxide (VPHP) technology that uses relatively dry hydrogen peroxide pulses is a promising method for the disinfection of surface-borne bacteria, yeasts, and molds on walnut nutmeats.

The number of colony forming units per gram (cfu/g) on untreated nutmeats was compared to those VPHP treated. Three culture media; dichloran rose bengal chloramphenicol agar base (DRBC, Oxoid), aerobic plate count agar (APC, Oxoid), and potato dextrose agar (PDA, Sigma), were utilized to evaluate cfu/g. Similar numbers of cfu/g of product were observed on APC and PDA. The more selective DRBC had lower cfu/g. Microorganisms washed from untreated walnut nutmeats purchased at retail outlets ranged between 17,000-29,000 cfu/g depending upon the culture medium used. The number of cfu/g on nutmeats after VPHP treatments was reduced to 500-1400, a 95% reduction. VPHP may offer an alternative to propylene oxide fumigation. The moisture content of nutmeats was not significantly altered by VPHP. The Food and Drug Administration lists hydrogen peroxide as a "generally recognized as safe substance" (GRAS). Hydrogen peroxide is already produced in a food grade for aseptic packaging.

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INHERITANCE OF SOME CHARACTERS IN OKRA

Seif H. Gad El-Hak*, Saved, H. Mahmoud, Mohamed A. Abobakr and Ragab M. Aiv. Dept. of Hort., Fac. of Agric., El-Minia Univ., El-Minia. Egypt.

Inheritance of plant height, leaf lobing index, internode length, and number of fruits per plant was studied. Four crosses (Pusa Swani X White Velvet and its reciprocal; Pusa Swani X Emerald: White Velvet X Emerald) were used in this investigation. The parents, F₁, F₂, and the first backcrosses populations were grown. The inheritance of all the studied characters was found to be quantitative. The proper statistical methods were followed for the analysis of all recorded data. It could be generally concludes that the narrow sense heritability in plant height ranged from 37.18 to 59.13%. leaf lobing index ranged from 26.35 to 77.73%; internode length ranged from 50.06 to 56.52%. and number of fruits per plant varied from 23.22 to 44.26%.

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ANTICOAGULANT ACTIVITY OF *ALLIUM* ACCESSIONS

I.L. Goldman and B.R. Schwartz, University of Wisconsin-Madison, Departments of Horticulture and Medical Sciences, Madison, WI 53706

In the past twenty years, the presence of blood anticoagulants in plants has been confirmed by a range of clinical and *in vitro* investigations. The presence of anti-clotting factors in plants presents a unique opportunity for dietary enhancement of circulatory and fibrinolysis. Experiments were conducted to assess variability in anticoagulant activity of a range of *Allium* wild species and cultivated accessions. Anticoagulant activity was determined via a platelet aggregation assay with human plasma. Extracts were prepared from 19 *Allium* species accessions and 24 cultivated accessions of *Allium cepa*, including standard inbred lines and open-pollinated populations. Relative inhibition of platelet aggregation was measured for each accession and inhibition constants (IC₅₀) were calculated. Data from this investigation demonstrate large IC₅₀ variability among accessions. Larger IC₅₀ differences (up to 45-fold) were measured among *A. cepa* accessions than among *Allium* species accessions (up to 16-fold). Yellow storage-type *A. cepa* accessions exhibited the strongest inhibitory activity. Implications of these findings to onion breeding and platelet function will be presented.

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GENETIC VARIABILITY FOR PRECOCIOUS PALM HEART YIELD OF PEJIBAYE IN HAWAII.

Charles R. Clement and Richard M. Manshardt*, Dept. Horticulture, University of Hawaii at Manoa, 3190 Maile Way, Honolulu, HI 96822

The pejibaye (*Bactris gasipaes*, Palmae) is being evaluated in Hawaii as a source of fresh hearts of palm. Nine open-pollinated progenies from the Benjamin Constant population of the Putumayo landrace are planted at three sites in a RCB. The best site started yielding at 15

months after planting, the intermediate at 16 months, the poorest at 18 months. During the first four months of harvest at the best site, 25% of the plants were cut; during three months at the intermediate site, 15% were cut; during the first cut at the poor site, 1% were cut. Progeny harvest percentages ranged from 7 to 53% at the best site, with only three progenies above average (33, 47, 53%). These are considered to be precocious. These three progenies produced average size hearts (172±36, 204±57, 203±44 g/plant, respectively; experimental mean±SD = 205±53 g), but yielded above average at 5000 plants/ha (275, 480, 524 kg/ha, respectively; exp. mean = 272 kg; corrected for % cut). Potential yields of these progenies were near the mean (871±198, 1018±280, 983±197 kg/ha, respectively; exp. mean = 986±381 kg/ha), but their precocity provides early returns to the farmer.

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COMPARISON OF OPEN-POLLINATED AND HYBRID CALABAZA

D.N. Maynard*, G.W. Elmstrom, J.K. Brecht, and L. Wessel-Beaver, Univ. of Florida, 5007 60th St. East, Bradenton, FL 34203 and Univ. of Puerto Rico, Mayaguez, PR 00681.

Bush and short-vined calabazas [*Cucurbita moschata* (Duchesne) Poir.] derived from crosses of 'Bush Butternut' with 'La Primera' and 'La Segunda' followed by several generations of selection and self pollination, are quite uniform in plant and fruit characteristics. Likewise, selfing and selection of vining cultigens has resulted in uniform vine and fruit characteristics. Hybrids between bush/short-vined and vining lines usually retain the plant habit of the bush/short-vined parent, and produce higher yields of fruit with thicker and better-colored flesh than open-pollinated cultigens. Hybrid bush/short-vined calabazas are earlier, have more concentrated fruit set, and utilize space better than open-pollinated cultigens. Commercial seed of hybrids is likely to be more readily available than seed of open pollinated cultigens.

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GENETICS OF FLOWERING TIME IN LETTUCE: CROSSES WITH C-2-1-1, HOMOZYGOUS FOR LATE FLOWER TIME.

Edward J. Ryder, USDA, ARS, 1636 E. Alisal St., Salinas, CA 93905.

In an earlier study, two genes controlled flowering time in certain lettuce crosses. Early alleles (Ef-1, Ef-2) at both loci are partially dominant; flowering time in the greenhouse ranges about 100 days from double dominant to double recessive. Crosses between C-2-1-1, a double recessive line, and four cultivars were analyzed to study further the distribution of these genes. Empire and Salinas flower at the same time as C-2-1-1, while Vanguard 75 and Prizehead are earlier than C-2-1-1. Empire x C-2-1-1 and Salinas x C-2-1-1 showed unimodal distribution in F₂, indicating segregation of several genes or environmental variation. A linear relationship between F₂ plant values and F₃ family means from both crosses suggested a polygenic basis. The F₂ distribution of Prizehead x C-2-1-1 was similar but showed a greater range of flowering times. An additional major gene was indicated in Vanguard 75 x C-2-1-1, with earliness recessive.

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CONSERVATION OF *PHASEOLUS* GERMPLASM FOR THE USDA, ARS, NATIONAL PLANT GERMPLASM SYSTEM

Richard M. Hannan*, USDA, ARS, Western Regional Plant Introduction Station (WRPIS), WSU, Pullman, WA 99164-6402

The *Phaseolus* collection is the largest collection maintained at WRPIS. It numbers 11,501 accessions with 1585 accessions pending PI assignment. Over 20% of the *Phaseolus* accessions must be handled in special ways because of unique pollination or day length requirements. In accordance with the stated mission of the project, evolution of the bean germplasm maintenance program has included the following innovations: 1. Expanded interaction with the international germplasm centers (i.e. CIAT) and national programs. 2. As a result of interactions with the *Phaseolus* CAC, the increase of this genus was moved to greenhouse production exclusively. 3. A program to clean up seedborne viruses in the *Phaseolus* collection was established. 4. For some of the wild species, it was necessary to establish suitable and reliable alternate regeneration sites. 5. In collaboration with the Bean Improvement

Cooperative (BIC) Bean Genetics Committee, WRPIS assumed responsibility for the Genetic Stocks Collection. 6. Develop a core subset of the *P. vulgaris* collection based on passport data, plant characters and molecular markers.

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INHERITANCE OF SPECIFIC AND ADULT PLANT RUST (*UROMYCES APPENDICULATUS*) RESISTANCE AND LEAF PUBESCENCE IN DRY BEAN (*PHASEOLUS VULGARIS* L.)

J.M. Bokosi*, D.P. Coyne¹, J. R. Steadman², E. Arnaud-Santana¹ and D. O'Keefe², Departments of Horticulture and Plant Pathology², University of Nebraska, Lincoln, NE 68583

An association between abaxial leaf pubescence (ALP) and adult plant resistance (APR) on trifoliolate leaves was reported previously. Recombinant inbred (RI) lines from crosses PC-50 (P1) with XAN-159 (P2) and BAC-6 (P3), and P3 with HT7719 (P4) were used to study the inheritance of specific resistance (SR), APR and ALP. P1 is resistant to A88TI-4b and has abaxial hairs on the trifoliolate leaves while P2, P3, and P4 are all susceptible (S) and have glabrous (G) leaves. P3 is resistant to D85C1-1. SR to A88TI-4b on primary leaves (PL) was determined by a single dominant gene with an additional dominant gene for APR on the 4th trifoliolate leaves in P1 X P2. ALP was governed by a single dominant gene with no association with APR. SR to A88TI-4b on PL in P1 X P3 was controlled by a single dominant gene. SR to DC85C1-1 on the PL was determined by a single dominant gene in P3 X P4.

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BREAKUP OF LINKAGES FOR DIAGNOSTIC TRAITS IN THREE-SPECIES CONGRUITY BACKCROSS (CBC) *PHASEOLUS* HYBRIDS

Neil O. Anderson and Peter D. Ascher*, Department of Horticultural Science, University of Minnesota, St. Paul, MN 55108

Advanced, two-species CBC individuals were used to create the first-ever, three-species hybrids between *P. acutifolius*, *P. coccineus* and *P. vulgaris*. M6 (2 species) x H15 (3 species) is the only three-species hybrid to date that segregates for diagnostic traits. Three generations of M6 (F₂, F₃, F₄) were used to create the series. Hybrid breakdown was most severe with M6 F₂ x H15, producing 100% cripples that died before anthesis. In M6 F₂ x H15 hybrids, segregation for stigma position, flower color, germination type, growth habit, leaf length/width ratios, and seed morphology commenced in the F₁ hybrid generation. F₁ phenotypes, with *P. coccineus* flowers & seeds and *P. acutifolius* leaves & growth habit, had severe hybrid breakdown with weak self compatibility; purple seed coats, with or without black circumdatus markings, and new flower colors were also produced. F₁'s with *P. vulgaris* growth habits were self-fertile and ceased segregating after the F₂.

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EVALUATION OF THREE DISEASE FORECASTING SYSTEMS FOR CON-I-ROLLING EARLY BLIGHT ON STAKED OR GROUND CULTURE TOMATOES IN NEW JERSEY

M.H. Maletta*, W.P. Cowgill, Jr., W. Tietjen, P. Nitzsche and S.A. Johnston, Rutgers Cooperative Extension of Hunterdon County, 4 Gauntt Place, Flemington, NJ 08822

Since 1990, FAST - Pennsylvania State University, CUFAST - Cornell University, and TOM-CAST - Ridgely College, Ontario, three systems for forecasting early blight, have been field tested at The Snyder Research and Extension Farm in northwestern New Jersey for their potential use in fresh market tomato production in that area of the state. In 1993, the number of fungicide applications for tomato early blight control required by the three forecast systems was less than the number required following a weekly schedule. FAST and CUFAST scheduled applications of chlorothalonil, 1.5 lb per acre, reduced disease severity, but TOM-CAST scheduled applications did not reduce disease severity compared to the untreated control. Culture did not affect disease control results but did affect disease incidence

and post-harvest losses. Total and marketable yields were not affected by fungicide application schedule. Potential cost savings of \$270 or \$465 per acre, resulting from reduced numbers of fungicide applications following CUFast or Fast, were estimated. Chemical name used: tetrachloroisophthalonitrile (chlorothalonil).

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CONTROL OF SOILBORNE ONION DISEASES WITH SOIL SOLARIZATION, FUMIGATION AND RESISTANT VARIETIES
Michael K. Thornton* and S. Krishna Mohan, University of Idaho, 29603 U of I Lane, Parma ID 83660

Pathogen populations, disease development and onion yield were compared in solarized, fumigated and non-treated plots during 1992 and 1993. Soil solarization was accomplished by covering plots with clear plastic for six weeks beginning in mid-August, prior to the year of onion production. Solarization was also combined with metham sodium, a plied prior to covering with plastic. Soil temperatures reached a maximum of 48°C at the 10 cm depth in solarized plots, and were consistently 10 to 15°C higher than in non-solarized plots. Disease resistant (Bravo) and susceptible (Valdez) onion cultivars were planted the following spring. Only the solarization + metham sodium treatment significantly controlled pink root and plate rot in 1992. In 1993, all solarization and fumigation treatments controlled pink root. Solarization and fumigation did not significantly increase yield in comparison to the check, except for the solarization + metham sodium treatment in 1992. Bravo exhibited lower disease incidence than Valdez in both years of the study. Bravo produced 32.7 t/ha and 6.2 t/ha higher yield than Valdez in 1992 and 1993, respectively.

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IMPROVED PERFORMANCE OF SHRUNKEN-2 SWEET CORN USING *TRICHODERM HARZIANUM* AS A BIOPROTECTANT.
Thomas Björkman*, Hugh C. Price, Gary E. Harman, James Ballerstein and Patricia Nielsen, Department of Horticultural Sciences, NYSAES, Cornell University, Geneva, NY 14456-0462

A strain of the biocontrol fungus *Trichoderma harzianum* was tested for effectiveness in improving the performance of *sh2* sweet corn using a variety of delivery methods. In greenhouse trials, *Trichoderma* seed treatment reduced the proportion of weak plants (unlikely to make a marketable ear) from 40% to 10%. This is evidence that the characteristically uneven stand establishment of supersweet corn should be overcome by using *Trichoderma*. In field trials, *Trichoderma* and *Gliocladium* (a related fungus) were inoculated as a seed treatment without fungicide in spring-tilled plots. Yields of uninoculated controls were 2.2, *Gliocladium*-treated were 2.6, and *Trichoderma*-treated were 3.6 T/ac. Delivering the same lines of fungus in the fall to a rye cover crop resulted in high populations the following spring. The cover crop was killed and fungicide-treated seed of 'Zenith' sweet corn was planted without tillage. Yield with *Trichoderma* was 4.0, with *Gliocladium* was 3.7, and uninoculated was 2.4 T/at. The uninoculated, conventionally-tilled plots also yielded 4 T/at. Thus the beneficial fungi overcame the inhibition caused by no-till. *Trichoderma* was delivered effectively both as a seed treatment and on a winter cover crop to improve stand uniformity and overall yield.

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STUDY OF THE ALLELOPATHIC PROPERTIES OF LYCOPERSICON HIRSUTUM. Eric B. Bish*, Thomas A. Bewick, and Donn G. Shilling¹ Horticultural Sciences Department and ¹Agronomy Department, University of Florida, Gainesville, FL 32611.

Laboratory experiments were conducted to evaluate the relationship between leaf area, leaf number, dry weight, and mg extract of *Lycopersicon hirsutum* (LA 1777) leaf washes and germination or root growth of common purslane (*Portulaca oleracea*) seeds. Additional experiments were conducted to determine the relationship between *L. hirsutum* (accessions 1777 and 1625) leaf washes and germination or root growth of common purslane seeds. Activity of separated sesquiterpenes from trichomes were compared to crude leaf washes. Results from the leaf washes of the *L. hirsutum* accessions (1777 and 1625) indicated that there was no significant difference between hexane leaf washes, methanol leaf washes, or crude leaf extracts when common purslane was used as the assay species. The accession 1777 was greater than 800 x more inhibitory to germination and greater than 300x more inhibitory to root growth of purslane seeds than accession 1625.

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GENOTYPIC DIFFERENCES IN THE INDUCTION OF DISEASE RESISTANCE WITHIN *CUCUMIS SATIVUS*

Lavetta Newell*, Irvin Widders and Raymond Hammerschmidt², Departments of Horticulture¹ and Botany and Plant Pathology², Michigan State University, East Lansing, MI 48824

Systemic resistance to necrotic lesion forming pathogens can be induced in certain plant species by inoculating a young leaf with a limited amount of pathogen or by treating with specific non-pesticidal chemical compounds. A physiological change correlated with the induced resistance response is an increase in the activity of acidic apoplastic peroxidases. When seedlings of 17 inbred lines of fresh market and pickling cucumbers were foliar treated with 20 ppm 2,6-dichloroisonicotinic acid (Ciba Geigy 41396) and subsequently inoculated with either *Pseudomonas syringae* pv. *lachrymans* or *Colletotrichum lagenarium*, significant differences were observed in the number of lesions that developed. CG 41396 treatment also gave rise to 4-fold (Producer and Early Russian), 3-fold (Poinsett and Straight 8) and 2-fold (Delcrow, WI 2757, TMG-1, TG 72) increases in peroxidase activity within inbred lines. Distinct changes in acid peroxidase electrophoretic isozyme banding patterns were observed within certain inbred lines after treatment with CG 41396. These results indicate that genetic variability exists within *Cucumis sativus* with respect to plant response to physiological disease resistance inducing treatments.

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COMPARING THE EFFICACY OF CHEMICAL CONTROLS FOR ROOT-KNOT NEMATODE ON WATERMELON.

G.E. Brust and W.D. Scott*, Purdue University, Southwest Purdue Ag. Center, Vincennes IN 47591.

Nine treatments, arranged in a RCB design with 4 replications on 20m rows/plot, were all soiled applied and incorporated under black polyethylene mulch, prior to planting. The treatments were: methyl bromide (MB) 98 and 67 & chloropicrin at 168 kgha⁻¹, metham sodium at 17 & 34 lha⁻¹, oxamyl at 1.6 & 3.2 lha⁻¹, fosthiazate 6.5 & 13 kgha⁻¹, and a control. Four week-old 'Crimson Sweet' watermelon (*Citrullus lanatus*) transplants were established 3 weeks after chemical applications were made. Soil samples were taken in the plastic row-middle, plastic edge, 30 cm off the plastic edge and 15, 30 & 45 cm deep at each sampling location 3 and 6 weeks after transplanting. The presence of Root-knot Nematode, RKN, (*Meloidogyne* spp.) was established by using 'Mountain Pride' tomato as a bioassay. Fruit size and total yield were recorded and the economic return for each control practice calculated. The 1.6 lha⁻¹ oxamyl plots yielded 6,832 kgha⁻¹ more than the control which corresponds to a return of \$183 for the investment of that control. The 3.2 lha⁻¹ plots had a yield increase of 7,728 kgha⁻¹ and a return of \$103, followed by, in order of yield response, 17 lha⁻¹ Metham plots, 18,592 kgha⁻¹ & \$498, 34 lha⁻¹ Metham plots, 25,872 & \$693, MB 67 plots, 35,952 kgha⁻¹ & \$752, and MB 98 plots, 37,072 kgha⁻¹ & \$851.

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OVERVIEW OF HERBICIDES AVAILABLE FOR CABBAGE PRODUCTION IN ILLINOIS AND WISCONSIN FOR THIRTY YEARS (1965-1994)

Herbert J. Hopen*, Department of Horticulture, University of Wisconsin-Madison 53706

Based on recommendations for commercial cabbage producers fourteen herbicides were labeled over the thirty year period of 1965 to 1994. The number of herbicide choices ranged from two in 1965 and 1982 to ten in 1993 and 1994. The ten herbicides labeled for use in Wisconsin in 1994 are clomazone, DCPA, glyphosate, metolachlor, napropamide, sethoxydim, trifluralin, oxyfluorfen, paraquat and pyridate. Thirty two candidate herbicides were evaluated in thirteen of the thirty years but have not been approved for use in cabbage production. State "emergency" and state "third party" labels will be discussed as a means to provide herbicides for specific grower uses. The efficacy of each of the labeled herbicides will be discussed as supported by field, greenhouse and laboratory studies.

Lee Fruits (Apples): Growth and Development

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WAX PLATELET ARRANGEMENT, GA₃ APPLICATIONS, AND THEIR RELATIONSHIPS TO RUSSET IN 'HARALSON' APPLES

Doug S. Foulk* and Emily E. Hoover, Department of Horticultural Science, University of Minnesota, St. Paul, MN 55108

'Haralson,' the most widely-grown cultivar in Minnesota, is highly susceptible to russetting and cracking in many orchards. Because wax platelet arrangement has been proposed as a cause for russetting in 'Golden Delicious' apples, we examined the wax platelet arrangement of 'Haralson' apples. When compared to the wax platelet arrangement found on the russet-susceptible 'Golden Delicious,' and on 'McIntosh,' a cultivar which does not russet in our region, 'Haralson' platelets were large and upright in orientation, more numerous than found on 'Golden Delicious,' but unlike the smaller, more granular platelets found on 'McIntosh.' In a concurrent study, we made four GA₃ (Provide) applications, at petal fall and at p.f. +10, 20, and 30 days. At harvest, the treated and untreated blocks of trees were examined for incidence of russet, 25-ct. wt., and total yield per tree. Treated trees produced a greater number of fruit of slightly larger size and with reduced incidence of russet than untreated trees in the study.

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INFLUENCE OF TEMPERATURE ON FRUITLET GROWTH OF APPLE

Ian J. Warrington*, Tina A. Schnell and Iona E. O'Brien, The Horticulture and Food Research Institute of New Zealand Ltd Private Bag 11 030. Palmerston North, New Zealand

The early growth responses of apple fruit to temperature were studied under controlled environment conditions. Growth of fruit on young trees of 'Fuji'/M.9 'Golden Delicious'/M.9, and 'Harold Red Delicious'/M.9 was frequently measured, over a 30-day period commencing 10 days after full bloom, under daily maximum/minimum temperatures of 22/12, 19/9, 16/6 and 13/3C. All other environmental conditions were maintained constant across all temperature treatments. Fruitlet diameter growth rate was approximately constant over the treatment period within each temperature regime and ranged from 0.24 mm day⁻¹ at 13/3C to 0.85 mm day⁻¹ at 22/12C. The growth responses to temperature were similar among cultivars but expansion rates were highest for 'Fuji' and lowest for 'Golden Delicious'. Cell division rates and durations, using flow cytometry, were measured over the treatment period and could be related to diameter growth rates. The impacts of temperature-induced differences in early fruit growth rates on final fruit size will be described.

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SINK ACTIVITY AND CARBOHYDRATE ALLOCATION PATTERNS WITHIN DEVELOPING APPLE FRUIT WITH AND WITHOUT FRUIT THINNING

Douglas D. Archbold, Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington, KY 40546-0091

Over 4 years, using estimates of fruit dry weight derived from diameter measurements *in situ*, cultivar variation in apple fruit relative growth rate (RGR) in the period following June drop was evident. These differences diminished as the season progressed however. Using estimates of dry weight per cell, fruit cell absolute growth rate increased over time and RGR showed no clear pattern in contrast to the RGR of whole fruit. There were no cultivar differences in carbohydrate allocation among the soluble, starch, and remaining ethanol-insoluble, non-hydrolyzable pools irrespective of cultivar RGR. The storage carbohydrate pool comprised an increasing fraction of the total dry weight over time with the starch pool comprising 10 to 25% of the storage carbohydrate, varying with season and cultivar. Neither fruit competition within a cluster nor post-June drop thinning altered fruit RGR or carbohydrate allocation patterns when compared to fruit thinned post-bloom.

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EFFECTS OF SEED NUMBER, TIME OF DEFRUITING, AND BOURSE SHOOT LENGTH ON FLOWERING IN APPLE.

John C. Neilsen* and Frank G. Dennis Jr., Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

Chan and Cain (Proc. ASHS 91:63-68, 1967) demonstrated that seeded apple fruits inhibited flowering, whereas seedless ones did not. 'Spencer Seedless' spurs bearing seeded or seedless fruits were defruited at various times after anthesis in 1989-1991 and fruit weight, seed number and bourse shoot length recorded, as well as repeat bloom. Similar defruiting treatments were also applied to entire 'Paulared' (all seeded fruits) trees in 1991 and 1992. In all years spurs bearing seedless fruits flowered the following year, regardless of defruiting time, shoot length or fruit weight per spur. Flowering of spurs bearing seeded fruits decreased as defruiting was delayed. In all years over 90% of spurs bearing fruits containing a total of 5 seeds or less flowered, whereas 90% of those with more than 5 seeds remained vegetative. Flowering was not correlated with shoot length or fruit weight. Bearing spurs of 'Paulared' flowered when whole trees were defruited within 60 days after anthesis, but flowering was greatly inhibited when fruits were left on for 97 and 74 days in 1991 and 1992, respectively.

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INTERACTION BETWEEN NAA AND BA ON CROPPING AND FRUIT SIZE IN 'DELICIOUS' AND 'EMPIRE' APPLES

Martin J. Bukovac, Brent L. Black, Jerome Hull, Jr.* and Matej Stopar, Dept. of Horticulture, Michigan State University, East Lansing, MI 48824

Benzyladenine (BA), reported to increase fruit growth in apples, was evaluated with NAA to overcome NAA-induced inhibition of fruit growth. High volume sprays of NAA (15 mg-liter⁻¹), BA (25 to 100 mg-liter⁻¹) and combinations were applied to Redchief 'Delicious' (king fruit = 10 mm). Yield was not significantly reduced. The combinations (NAA + BA 25, 50 or 100 mg-liter⁻¹) resulted in the highest percentage of small fruit (39% < 70 mm) and the lowest percentage of large fruit (35% > 77 mm) compared to NAA, BA and hand thinned control. There was no significant effect of NAA or BA on size of king fruit in absence of lateral fruit competition on a given spur, while the combinations decreased (P = 0.01) king fruit size. NAA, but not BA, reduced growth of lateral fruit, with or without competition. However, the combinations caused marked suppression of lateral fruit growth and reduced seed content. With 'Empire', both NAA (10 mg-liter⁻¹) and BA (25 to 150 mg-liter⁻¹) effectively thinned. Fruit size was greater with BA than NAA. The combinations (NAA, 10 mg-liter⁻¹ + BA, 25 or 50 mg-liter⁻¹) over-thinned and did not increase the amount of small fruit as in 'Delicious'.

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EFFECTS OF NAA ON FRUIT SIZE OF 'DELICIOUS' APPLES

Brent L. Black*, Martin J. Bukovac and Jerome Hull, Jr., Department of Horticulture, Michigan State University, East Lansing, MI 48824

Post-bloom fruit thinning of spur-type 'Delicious' with NAA may occasionally result in excessive small fruit (50 - 67 mm) not correlated with crop load. We evaluated the effect of carrier volume and time of application on incidence of small fruit over three growing seasons. A constant dose of NAA (30 g-ha⁻¹) was applied in 230 to 2100 liter-ha⁻¹ at about 10 mm king fruit diameter (KFD). Amount of NAA-induced small fruit differed from year to year, but there was no significant effect of carrier volume in any given year. NAA (15 mg-liter⁻¹) was applied as a dilute spray at 5 to 22 mm KFD. Time of application influenced fruit size distribution at harvest in only one of three years. The incidence of small fruit appeared more closely related to temperature during spray application than to carrier volume or time of application. The effect of NAA on growth rate of king fruit with minimal competition (branches hand thinned, no lateral fruit) was determined over the first month after thinning. There was no pronounced effect of NAA on post-treatment growth rate. In a related study, NAA caused a significant decrease in fruit size when two or more fruit were competing on the same spur, while fruit size in the absence of intra-spur competition was not significantly reduced.

CHALCONE SYNTHASE AND UDPG GLUCOSYL-TRANSFERASE REGULATE ANTHOCYANIN SYNTHESIS IN APPLE
Zhiguo Ju, Laiyang Agricultural College, Shandong, China
Delicious apples were harvested and analyzed every 7 days from the start of fruit coloration to commercial harvest. Chalcone synthase (CS) activity increased from 521 to 4120 fkat/g protein during 30 days, while UDPG glucosyltransferase (UDPGTF) activity increased from 0 to 6570 fkat/g protein. These changes significantly correlated with anthocyanin synthesis in fruit skin. Ethephon enhanced activities of both enzymes for 25 days after application, but not beyond. Cycloheximide inhibited CS and UDPGTF activities by 57% and 72%, respectively, and this could not be overcome by ethephon treatment. Bagging prevented fruit from coloring, and removing bags before maturation promoted it. Activity of both enzymes was nil in bagged fruit, and increased dramatically after bag removal. Cycloheximide applied at bag removal reduced CS and UDPGTF activities 74% and 91%, respectively, and decreased anthocyanin synthesis by 82%. The results showed that both CS and UDPGTF were positively correlated with anthocyanin formation and both required de novo synthesis during fruit coloring, although CS had existed before that.

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ELECTROLYTE LEAKAGE FROM INDIVIDUAL MAIZE AND WHEAT SEEDS TO PREDICT GERMINATION PERCENTAGE AND RADICLE LENGTH
K.G.V. Davidson*, F.D. Moore, III and E.E. Roos, Department of Horticulture, Colorado State University, and USDA-ARS National Seed Storage Laboratory, Fort Collins, CO 80521

Multiple electroconductivity readings (μ Amperes) of leachates from individual seeds during the first 6 hr of imbibition was examined as a possible predictor of seed quality. Readings from each sample of 100 seeds were formed into frequency distributions and the mean, median, and internal slope were calculated using an automated computer retrieval system. Internal slope is a non-central tendency measure based on the slope of a line tangent to the inflection point of the S-shaped cumulative frequency distribution (CFD) of μ Amperes. Radicle lengths (3 days) and germination (7 days) percentages were regressed on each of the two measures of central tendency and also the CFD shape indicator, internal slope. None of the three predictors were satisfactory for estimating seed vigor (root lengths) of maize (*Zea mays* L.) or wheat (*Triticum aestivum* L.) or germination of wheat seed lots. Internal slope was useful in estimating viability of artificially aged maize seeds ($r^2 = 0.91$), which compared favorably with our previous results using naturally aged red clover (*Trifolium pratense* L.) seed lots. Overall the seed quality of the unaged wheat lots was fairly high and the electrolyte leakage test was not sensitive enough to detect differences within these lots.

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UV-B INDUCED CHANGES IN PHENYLALANINE AMMONIA-LYASE (PAL) ACTIVITY AND UV-ABSORBING COMPOUNDS IN COTTON AND CUCUMBER SEEDLINGS

Donald T. Krizek*, Abha Upadhyaya, and Roman M. Mirecki, Climate Stress Laboratory, NRI, ARS, U. S. Department of Agriculture, Beltsville, MD 20705-2350

UV-B (UV) induced changes in PAL activity and UV-absorbing compounds were followed in cotton after 1 to 9 days and in cucumber after 1 to 14 days. UV increased PAL activity in the lower hypocotyl (LH) of cotton but had no effect on the upper portion. In general, PAL decreased with time, but UV treatment slowed that decline in the LH portion. Anthocyanin concentration declined with time in both portions. In cucumber cotyledons, UV had no effect on PAL. In cucumber leaves, there was no overall effect of UV; but there were significant interactions with time. In both cotyledons and in leaves, PAL decreased with time. As in LH cotton tissue, UV slowed the rate of decline of PAL in cucumber leaves. In leaves, UV absorbing compounds (at 330 nm) were increased by UV; in cotyledons, the increase in absorption was greater in controls than in UV-B irradiated seedlings. In cotton, changes in anthocyanins mirrored those in PAL, this was not the case for UV absorbing compounds in either species.

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C AND N FLUXES IN BRUSSELS SPROUTS (*BRASSICA OLERACEA* VAR. *GEMMIFERA*) DURING BUD GROWTH

Remie Booi*, and Bert Meurs, DLO-Research Institute for Agrobiology and Soil Fertility (AB-DLO), P.O. Box 14, 6700 AA Wageningen, The Netherlands

The harvest season for Brussels sprouts runs mainly from September to March. During this period the daylength is relatively short and the light intensity is low. Bud growth occurs, when photosynthesis is low. The question is, whether actual photosynthetic rate or redistribution of earlier fixed photosynthates is the main source for bud growth. The aim of the present experiment was first to determine the gain of C and N and the distribution of these plant constituents within the plant, and second the role of the apical bud. Partitioning of dry matter over the plant parts and the allocation along the stem were determined. Contents of C, N, NO₃ and soluble sugars in the dry matter were ascertained, and the total amounts of these components could be determined. From this analysis fluxes were calculated and the role of redistribution was investigated. Redistribution of soluble sugars and N from leaves before shedding contributed substantially to bud growth. The apical bud did not affect total dry matter production, but if removed, more dry matter became available for bud growth in the top region of the plant, resulting in a higher total bud yield.

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POLLINATION AND FRUITSET PATTERNS OF FIELD-GROWN PUMPKINS

S. W. Cady*, H. C. Wien; Dept. of Fruit and Vegetable Science, Cornell University; Ithaca, NY

Investigations of varietal differences in pumpkin flowering and fruitset patterns were initiated in response to reports of poor fruitset by NYS growers. In addition, pollination requirements for marketable fruit were explored in one cultivar. Flowering date, fruitset, and fruit characteristics were recorded for 2 consecutive years in a RCBD of six popular *Cucurbita pepo* cultivars (Wizard, Happy Jack, Autumn Gold, Ghost Rider, Howden and Baby Bear). On average, female blossoms opened 38 days after 3-wk-old seedlings were transplanted into the field. Flowering period lasted for 3 to 4 weeks. No consistent pattern was found in female flower production nor fruitset until the last week when significant declines occurred. Each blossom only opens for one day and typically closes between 10 am and noon, limiting pollination opportunities. Hand-pollination of 'Wizard' with various dilutions of pollen revealed that a minimum of approximately 2000 grains of pollen is necessary for fruitset. Removal of 66-75% of the stigmatic surfaces did not affect seed number or their location in the fruit, nor fruit shape or size. Fruit size was not correlated with seed number, although no fruit developed with less than 100 seed.

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VARIATION IN SUMMER SQUASH FLOWERING IN RESPONSE TO ENVIRONMENT
D. Scott NeSmith, The University of Georgia, Department of Horticulture, Georgia Experiment Station, Griffin, GA 30223

Research over a two year period assessed the influence of planting date and location on time to flowering and number of flowers produced for five summer squash (*Cucurbita pepo* L.) cultivars. Heat units (HU) were calculated using a single equation to determine if this approach could account for a significant portion of the variability in time to onset of flowering over the range of environments. Depending on cultivar and flower sex, the number of days to flowering varied as much as 20 days. There were significant cultivar differences in HU required for the onset of both staminate and pistillate flowers. The use of HU instead of days reduced the variability of time to flowering as indicated by regression analyses and mean absolute differences between predicted and observed days to flowering. The total number of staminate flowers produced was more variable than that of pistillate flowers. The ratio of pistillate-to-staminate flowers was stable for two of the five cultivars; however, pistillate flower production for those two cultivars was severely restricted during hot weather. Thus environment has a considerable influence on both the onset of flowering and the number of flowers produced for summer squash.

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COMPARISON OF HORTICULTURAL CROPS GROWN AT TWO ROOT-ZONE TEMPERATURES

Kimberly A. Klock*, Henry G. Taber, and William R. Graves
Horticulture Department, Iowa State University, Ames, IA 50011

Two root-zone temperatures (RZT) treatments, 21C and 34C were compared to evaluate their effects on growth and nutrient uptake for tomato (*Lycopersicon esculatum* Mill.), muskmelon (*Cucumis melo*

L.), honey locust (*Gleditsia triacanthos* var. *inermis* Willd.), and geranium (*Pelargonium hortorum* L.H. Bailey). Plants were grown in a specialized hydroponic system with full strength Hoagland's No. 1 solution. RZT were initiated after a 7 day acclimation period and were held at the respective RZT continuously. Significant differences among the species were expected and noted for growth parameters of fresh wt., dry wt. of shoot and root, and elemental uptake. The 34C RZT, compared with 21C, reduced root length by 22, 51, and 57% for honey locust, tomato, and melon, respectively. P uptake rate dropped to 0 at 34C, as compared to 1.86 mg P/g root/day at 21C for melon. P uptake rate of the other crops was not affected by RZT.

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PRESSURE OF SAP EXUDATE OF TOMATO PLANTS IN VARIED ROOT ENVIRONMENTS

Fude Yao* and Kenneth Corey, Department of Plant & Soil Sciences, University of Massachusetts, Amherst, MA 01003

Sap pressure of cut tomato stems was monitored using a real time data acquisition system to assess changes in the root zone environment. Hydroponically-grown tomato plants were cut and a gas-free connection made to a temperature-compensated pressure transducer. When plants were bathed in nutrient solution under isothermal conditions, pressure increased to a maximum within 10 to 75 min; maxima varied in the range of 20 kPa to 150 kPa. A fatigue phenomenon occurred with all plants, exhibited by decreases in pressure maxima over time. When root zone aeration was stopped or a nitrogen atmosphere was used, pressure dropped following a lag of about 30 min. This decrease in pressure was partially reversible when aeration was resupplied. Near instantaneous changes in sap pressure occurred when the root zone was manipulated by imposing a temperature gradient or by increasing the osmolarity of the solution. The technique reported may be useful for continuous monitoring of changes in the root zone environment and in assessing plant health.

responsive. In leaf tissue L-221 was repressed by zeatin, benzyladenine and thidiazuron at 50 μ M. In suspension cell culture mRNA abundance of L-221 remained constant regardless of cytokinin treatment. By contrast, the abundance of L-22 mRNA was increased differentially by treatment with each of the 3 cytokinins in leaf tissue. Suspension cells analyzed for expression of L-22 after cytokinin treatment also showed differential gene expression. S-1 Nuclease Protection Assays revealed that gene expression is a transient phenomenon dependent upon the time of cytokinin application and cytokinin concentration. Callus bioassays showed that dihydrozeatin and O-glucosylzeatin gave greater responses than the co-application of zeatin and dihydrozeatin or zeatin and O-glucosylzeatin. The conjugate and the reduction derivative also gave greater responses than zeatin alone. Effects of dihydrozeatin and O-glucosylzeatin on gene expression will be reported.

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IMMUNOLocalIZATION AND GENE CLONING OF ZEATIN O-XYLOSYLTRANSFERASE

Ruth C. Martin,* Machteld C. Mok, and David W.S. Mok, Dept of Horticulture, Oregon State University, Corvallis, OR 97331-7304

Cytokinins are widely used in tissue culture and transformation systems; however, little is known of their mode of action or the mechanisms regulating their levels in plant tissues. We are studying enzymes responsible for the metabolism of zeatin in immature seeds of *Phaseolus*. Selective expression of genes encoding such enzymes may regulate the level of active cytokinins during seed development as well as in in vitro systems. A zeatin O-xylosyltransferase, which mediates the formation of O-xylosylzeatin from *trans*-zeatin and UDP-xylose, has been isolated and monoclonal antibodies specific to the enzyme have been produced. Tissue print analyses demonstrated that the enzyme is primarily localized in the endosperm. *In situ* localization and EM studies indicated that the enzyme is present in the cytoplasm and the nucleus. cDNA libraries were constructed from immature seed mRNA and immunopositive clones were selected. The products of these clones are being analyzed in *E. coli* and baculovirus expression systems.

309

GENOMIC ANALYSIS OF TWO FUNGI CAUSING ANTHRACNOSE OF DOGWOOD (CORNUS SPECIES) IN THE EASTERN UNITED STATES

R. N. Trigiano*, G. Caetano-Anollés, B. J. Bassam and M. T. Windham.

Institute of Agriculture, The University of Tennessee, Knoxville, TN 37901-1071

DNA Amplification Fingerprinting (DAF) was used to characterize ten isolates of *Discula destructiva* Redlin and three isolates of an undescribed species of *Discula*, the causal organisms of dogwood (*Cornus* species) anthracnose. Isolates were obtained throughout the disease range in the eastern United States and DAF profiles generated with ten arbitrary oligonucleotide primers. Very few polymorphic loci (27/298) were detected between isolates of *D. destructiva*; whereas, a greater number were observed between and among the isolates of *Discula* species. Relationships among and between the two fungal groups were analyzed using PAUP and UPGMA and indicate that the genome of *D. destructiva* is highly conserved throughout the distribution. In contrast, isolates of *Discula* species exhibited greater variability. This suggests that *D. destructiva* was recently introduced to the eastern United States.

310

IN SITU GENETIC COMPLEMENTATION OF FLOWER COLOR MUTATIONS VIA PARTICLE BOMBARDMENT

R. J. Griesbach, Floral and Nursery Plant Research, U.S. National Arboretum, U.S.D.A., BARC-WEST, Beltsville, MD 20705-2350

Genetic complementation was used to correct the albescent flower color mutation of the orchid *Doritis pulcherrima*. The *Zea mays* anthocyanin regulatory genes *C1* and *B* were introduced into the petal cells via particle bombardment. Anthocyanin pigmentation developed within the bombarded cells after 48 hours. This suggests that the albescent phenotype was the result of a defective regulatory gene(s) and not the result of a defective structural gene(s). Genetic complementation via particle bombardment requires considerably less time than via classical breeding and could be used on other species or with other genes.

147 ORAL SESSION 43 (Abstr. 306-311) Genes: Gene Expression

306

DECREASED ETHYLENE SYNTHESIS AND ALTERED FRUIT RIPENING IN TRANSGENIC TOMATOES EXPRESSING S-ADENOSYLMETHIONINE HYDROLASE

Richard Bestwick*, X. Good, J. Kelloog, D. Langhoff, W. Matsumura, W. Wagoner and G. Cloud, AgriPro, Inc., 8505 SW Creekside Pl., Beaverton OR, 97005 and HAREC, Oregon State University, Hermiston, OR 97838

The gene encoding S-adenosylmethionine hydrolase (SAMase) was transferred to tomato (*Lycopersicon esculentum*, cv. large red cherry) as a means of reducing ethylene biosynthesis in the ripening fruit. S-adenosylmethionine (SAM), the penultimate precursor to ethylene in plants, is converted to methylthioadenosine and homoserine by SAMase thereby reducing the capacity of the transgenic plant to synthesize ethylene. We have used both constitutive and fruit-specific tomato promoters to regulate SAMase gene expression. Whereas the constitutive CaMV 35S:SAMase chimeric gene expressed active SAMase and conferred a 50-60% reduction in ethylene biosynthesis in a leaf disc assay, there was little effect on fruit ethylene synthesis or postharvest ripening physiology. The use of either the tomato E4 or E8 promoters restricted SAMase expression to ripening fruit which caused a substantial (80-90%) reduction in fruit ethylene synthesis and a profound effect on fruit ripening. SAMase expression levels reached 0.1% of total cellular protein as measured on western blots using anti-SAMase monoclonal antibodies. Field trial fruit picked at the mature green stage accumulated less lycopene and were twice as firm as controls over a six week period. Vine-ripened fruit had near-normal levels of lycopene, were firmer at harvest than controls, and did not lose firmness over a two week period. Taste, vitamin content and tomatine content were superior or equivalent to control tomatoes.

307

CYTOKININ-RESPONSIVE GENES IN *Phaseolus vulgaris*. Kerrie McDaniel* and David Lightfoot, Southern Illinois University at Carbondale, IL 62901.

Physiological differences between cytokinins are well documented. An explanation for these differences is that cytokinins differentially regulate genes. Gene response has been analyzed in cell culture and organized tissue of *Phaseolus vulgaris* L. cv. Great Northern. Two novel cDNAs, L-221 and L-22, have been identified that are cytokinin

GENETIC AND MOLECULAR STUDIES OF DINITROANILINE HERBICIDE-RESISTANT GOOSEGRASS [*Eleusine indica* (L.) Gaertn.]. L. Zeng, K. S. Mysore and Wm. Vance Baird*. Dept. of Horticulture, Box 340375, Clemson University, Clemson, South Carolina 29634-0375.

Goosegrass (Poaceae) is a member of a small but economically important genus, containing approximately 10 species. Goosegrass is a noxious weed in cotton, soybean and turf production, but was effectively controlled by the application of dinitroaniline herbicides (DNH). However, in the early 1970's two DNH tolerant biotypes were discovered. The highly resistant (R-) biotype is now found in many areas in the southeastern US, while the intermediately resistant (I-) biotype is known only from SC. We have investigated the inheritance and expression of resistance, using radicle/root growth bioassays, in F2 progeny derived from F1 hybrids (created by outcrossing this autogamous weed). The hybrid nature of presumptive F1 seedlings was confirmed by isoenzyme analysis. The DNH's effect their herbicidal action by disrupting the assembly of tubulin dimers into microtubules (MTs). The R-biotype has been shown to possess MTs that are hyperstable in the presence of the herbicide. Mutation(s) in a tubulin protein would be manifested in the gene and might be detectable at the nucleic acid level. We found that the alpha-, beta- and gamma-tubulins are encoded by multigene families (~ 5.7 and 8 members, respectively). DNA polymorphisms were detected, but were not strictly correlated with biotype. Therefore, the differences in herbicide response phenotype cannot be attributed to large deletions and/or insertions in a tubulin gene(s).

168 ORAL SESSION 44 (Abstr. 312-318) Tree Fruits: Rootstocks

312

FLUID STRESS RESPONSES OF YOUNG APPLE TREES ON 3 ROOTSTOCKS
R.T. Fernandez*, R.M. McLean, R.L. Perry and J.A. Flore, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325.

'Jonnee' on M.9 EMLA, M.26 EMLA and Mark rootstocks were subjected to flooding for 2, 4, 8, 16 and 32 days duration. Recovery was monitored after each stress period until 28 days after the 32 day flood stress. The objectives were to determine growth and physiological adaptation of the three rootstocks to flooding. Gas exchange, root dynamics, leaf area and emergence, and shoot length were measured for each stress and recovery period. CO₂ assimilation initially was increased for flooded treatments of Mark and M.9 EMLA up to 300% and 200% of controls until three days after flooding. After 4 days of flooding, CO₂ assimilation decreased to 30% or less of controls for both rootstocks. No initial increase was seen for flooded M.26 EMLA, rather a steady decline until net respiration occurred. Root number was not affected until 32 days of flooding where all flooded treatments had fewer roots counted compared to controls. After release from flooding trees on Mark recovered root growth while M.9 EMLA and M.26 EMLA continued to decline in root numbers. Shoot system growth of flooded trees on M.26 EMLA was reduced first and to the greatest extent followed by Mark and then M.9 EMLA.

313

PERFORMANCE OF 'STARKSPUR SUPREME' ON 15 APPLE ROOTSTOCKS OVER 10 YEARS AT 28 LOCATIONS IN THE NC-140 TRIAL.
D.C. Ferree* Department of Horticulture, Ohio State University Wooster, OH 44691

In 1984 trees of 'Starkspur Supreme Delicious' apple on 15 rootstocks were planted at 28 locations in North America according to guidelines established by The North Central Regional Cooperative Project (NC-140). The largest trees were on P.18, ANT.313, B.490 and seedling. Producing trees approximately 70% the size of seedling were rootstocks P.1 and M.7 EMLA while M.26 EMLA and C.6 were 50% the size of seedling. A group of rootstocks 30% the size of seedling or smaller were B.9, MAC.39, P.22, P.2, P.16. Rootstocks with high production efficiency were P.16, 8.9, P.22, P.2 and C.6. Rootstocks with low production efficiency similar to apple seedling were MAC.1, M.4., B.490, P.18 and ANT.313.

314

ROOTSTOCK EFFECTS ON SHOOT MORPHOLOGY OF 'DELICIOUS' APPLE

Peter M. Hirst* and David C. Ferree, Ohio Agricultural Research and Development Center, The Ohio State University, 1680 Madison Avenue, Wooster, OH 44691.

One way in which rootstocks may influence production efficiency is by altering the number of spurs, and in particular reproductive spurs. However, rootstock influences on the morphology of shoots have not been quantified. Measurements were made on 'Starkspur Supreme Delicious' trees growing on 17 rootstocks and planted in 1984 as part of the NC-140 regional rootstock trial. In each of the 6 years from 1988-1993, the length of the 2-year old section of wood of selected branches was measured and the number of spurs, flowers and shoots counted. For all rootstocks, trunk cross-sectional area was closely related to shoot length. Trees on P.22 (the most dwarfing rootstock in the planting) had shoot lengths 40-50% of those of trees on seedling rootstocks. For each rootstock, there was a strong negative relationship between shoot length and spur density, but there was not a common relationship among rootstocks. Similarly, flower number per shoot was also related to shoot length with different relationships for each rootstock. Flower density was not related to vigor for any of the rootstocks.

315

TISSUE PROLIFERATION ON MARK ROOTSTOCK SHANKS: EFFECT ON TREE GROWTH, AND CORRELATION WITH SITE FACTORS

E.W. Stover* and C.S. Walsh¹ Dept. of Hort. Sci., Cornell U., P.O.Box 727, Highland, NY 12528. ¹Dept. of Hort., U of Maryland, College Park MD 20742

A factorial planting of three scion varieties ('Gala', 'Fuji', and 'Braeburn') on each of four rootstocks (Mark, M.26, M.7a, and MM.11) was established at two locations in MD in 1990. In 1993, trees were scored for trunk circumference (TC), extension growth, leaf color, burrknots (BK) and gall-like swellings (GLS) both above and below ground, and presence of pests on the shanks. Mark was the only rootstock with GLS; 75% of the trees examined had these tissue proliferations, Mark grafted with 'Fuji' had 2-3X higher %TC composed of GLS below ground than was observed with other scion varieties. Across rootstocks, %TC composed of BK below ground was significantly affected by location. In each rootstock, regressions between growth parameters and % of TC with BK or GLS were almost all negative and many had significant correlations. In Mark, % of TC with GLS below ground (but not above) was significantly correlated with reduced TC at 25 cm. The occurrence of GLS was much greater below ground than above. Orchard surveys of trees on Mark were also conducted at several commercial sites in MD and NY. The percentage of trees showing GLS ranged from 0 to 90%. There was a significant reduction in TC at 25 cm correlated with increasing levels of GLS. The percentage of trees with GLS and mean % of TC with GLS significantly correlated with percentage of trees having visible woolly apple aphids or their distinctive galls.

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ROOTSTOCK AFFECTS RIPENING OF 'MCINTOSH' APPLES

Wesley R. Autio*, Department of Plant & Soil Sciences, 205 Bowditch Hall, University of Massachusetts, Amherst, MA 01003

'Summerland Red McIntosh' apple trees propagated on M.9/A.2/O.3, M.7 EMLA, M.26 EMLA, M.7A, OAR1, or Mark rootstocks were planted in 1985 in a randomized complete block design with seven replications. Fruit ripening and quality were assessed in 1988-93. Internal ethylene concentrations were measured weekly throughout each harvest season. Once each season, fruit weight, starch-index value, soluble solids concentration, flesh firmness, and surface ted color were assessed on a sample of fruit from each tree. Size was smallest for fruit from trees on OAR1 or Mark, after accounting for the effects of crop load with analysis of covariance. Surface ted color was greatest for fruit from trees on Mark and least for fruit from trees on M.7 EMLA. Ripening was variable, but generally, fruit from trees on 0.3 ripened first, and fruit from trees on M.7 EMLA or M.7A ripened last. Crop load impacted ripening, but its effects were removed with analysis of covariance.

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PERFORMANCE OF FOUR APPLE CULTIVARS GRAFTED ON FOUR ROOTSTOCKS

Raymond L. Granger*, Shahrokh Khanizadeh and Yvon Groleau
Agriculture Canada Research Station, St-Jean-sur-Richelieu, Quebec, J3B 3E6

In 1988 a randomized complete block design with five blocks was used to evaluate the performance of four cultivars ('Empire', 'Cortland', 'Summerland McIntosh' and 'Lobo') grafted on four rootstocks {Budagovsky(Bud.)9, Mallings(M.)7,Ottawa(O.)3 and Mallings Merton(M.M.)111}. The sixteen cultivar-rootstock combinations were planted randomly at 2.5m apart in the row. The

distance between the rows was 5m. The trees have been trickle irrigated every year and came into bearing in 1990. On the basis of cumulative yield efficiency the combination 'Lobo'/O.3 was significantly superior to all others. The second best performer was 'Empire'/O.3 followed by 'Lobo'/Bud9. 'Empire' MM.111, 'Summerland McIntosh'/M.M.111, 'Cortland'/M.M.111, 'Summerland McIntosh'/M.7 and 'Empire'/M.7 had the least cumulative yield efficiency. Generally the cultivar 'Lobo' was superior to others and O.3 was the best rootstock followed by Bud.9, M.7 and M.M.111.

318 FIELD PERFORMANCE OF 28 PRUNUS ROOTSTOCKS AND INTERSTEMS IN SOUTH CAROLINA

Gregory L. Reighard*, Clemson University, Department of Horticulture, Box 340375, Clemson, SC 29634

A 'Redglobe' peach orchard budded to 22 rootstock cultivars was planted in 198X on a Lakeland sand near Columbia, SC. Six of the 22 cultivars were also used as interstems on Nemaguard. The rootstocks tested were Lovell, Halford, Nemaguard, Bailey, Tennessee Natural, Tzim Pee Tao, Rutgers Redleaf, Higama, Rubira, Montclar, GF 305, Juseito, Myran, Ishtara, S.2729, St. Julian A, Citation, Marianna 2624, GF 557, GF 677, (SxR 185)6 and 'Redglobe' own-rooted. Trees on Marianna 2624 grew poorly and eventually died from incompatibility. Plum hybrid rootstocks St. Julian A, Ishtara and Myran were susceptible to *Pseudomonas syringae*. Some peach X almond (SxR 185)6 trees died from unknown causes. Tzim Pee Tao was the only rootstock to delay bloom significantly later (1.5 days) than Lovell. All Nemaguard interstem combinations and Tzim Pee Tao had significantly more-rootstock suckers. Nemaguard, Myran and Higama trees were 25 to 43% larger in TCSA than Lovell. Ishtara trees were only 61% of Lovell in TCSA. St. Julian A and Citation trees were small, weak and unproductive. The highest yielding rootstocks were Nemaguard (Myran interstem), GF 305, Nemaguard (Ishtara interstem), Montclar and Rubira which averaged 69, 65, 64, 62 and 60 kg/tree, respectively in years 4 through 6.

169 ORAL SESSION 45 (Abstr. 319-324) Tree Fruits and Nuts: Flowering and Fruiting

319 CONTROL OF FLORAL DEVELOPMENT IN APRICOT AND PEACH BY GIBBERELLIN

Kitren G. Weis*, Stephen M. Southwick and George C. Martin, Pomology Department, University of California, Davis, CA 95616

Gibberellic acid reduces return bloom in many fruit tree species. Reducing bloom may cut costs of hand thinning apricot, peach and plum fruit. Sprays of 250 ppm GA₃ during floral bud evocation (June 1993) resulted in bud death and abscission as determined by light microscopy sections in 'Patterson' apricot (*Prunus armeniaca* L.). GA treatment in May did not cause observable effects. August treatments, immediately prior to floral initiation, did not impede differentiation. Treatment of 'Elegant Lady' peach (*Prunus persica* [L.] Batsch.) buds with 75-250 ppm GA₃ in late June, 1993 (evocation phase) did not have any discernable effects in that season with respect to abscission or differentiation. Treated peach buds differentiated simultaneously with untreated buds in early August. The patterns of response to GA treatment imply 'windows of opportunity' with respect to effectiveness of GA treatments. The specific response suggests that apricot buds possess differing levels of sensitivity to GA treatment and probably reflect distinct phases in transition to flowering. In August buds were already 'determined' and were in a potentially floral state that was irreversible.

320 REPRODUCTIVE DEVELOPMENT AND FRUIT QUALITY OF SWEET CHERRY

Preston K. Andrews* and Margaret L. Collier, Dept. of Horticulture and Landscape Architecture, Washington State Univ., Pullman, WA 99164

Variability in maturity and quality of sweet cherry (*Prunus avium* L. 'Bing') fruit at harvest is a major limitation to the crop's storage and marketing potential. Later blooming flowers resulted in poorer fruit quality. Differences in bloom date were related to differences in flower primordial

development during winter. Vigorous shoots grown in the previous season produced fewer flower buds per length of shoot than did shorter, less vigorous shoots, resulting in larger flower primordia on vigorous shoots. The effects on primordial and fruit development of altered leaf areas per flower bud the previous summer were examined. A decrease in leaf area per bud during summer reduced primordium size in mid-winter. Dormant flower primordia of 6-yr-old 'Bing' trees on precocious 'Giessen' rootstock, Gil48/1, were larger than those with 'Mazzard' as rootstock. Flower primordia on dwarfing Gil48/8 rootstock were intermediate in size. Differences in primordial development and bloom date, whether due to management practices or rootstock, may affect fruit development and contribute to variability in fruit maturity and quality.

321 GIBBERELLIN METABOLISM AND FLOWERING IN APPLE

Jun Ban* and Frank G. Dennis Jr., Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

Some apple cultivars are biennial. Experiments with the facultatively parthenocarpic apple cultivar 'Spencer Seedless' indicated that seeds are responsible for inhibiting flowering (Chan and Cain, Proc. ASHS 91:63-68, 1967). Because gibberellin inhibits flowering in apple, seed GAs may be responsible for biennial bearing, or seeds may affect metabolism of GAs in bourse shoots. To obtain additional information, ¹⁴C-GA₃ was injected into seeds or bourse shoots of 'Spencer Seedless' and the metabolites were extracted after 24 or 48 hr. Metabolites moved from seeds to bourse shoots and vice versa in 1992, only the most polar compound(s) being transported. However, transport was not observed in 1993. Five metabolites of ¹⁴C-GA₃ were found in apices following injection, 5 to 7 in seeds. Two metabolites occurred in fruit flesh following seed treatment. The presence of seeds appeared to have no qualitative effect on metabolism in the bourse shoot, although the metabolites have not yet been identified.

322 WHY DOES SOUR CHERRY (*Prunus cerasus*) PRODUCE SO MANY MORE FLOWERS THAN FRUITS?

A. Kahn, A.F. Iezzoni*, S. Kalisz, CA. Mulinix, and V. Delasalle, Michigan State University, East Lansing, MI 48824

The number of flowers produced by sour cherry greatly exceeds the number of fruits developed. Two hypotheses to explain this disparity were investigated: (1) pollen may be limiting, and (2) a large flower display is important for pollinator attraction. Self-incompatibility, which is common in sour cherry, was considered. Fruit set, floral morphology, and flower density were measured on 18 sour cherry selections, both self-compatible and self-incompatible (SI), in the MSU sour cherry germplasm collection following open- and bulk-pollination. Although supplemental hand pollination resulted in a significant increase in fruit set, the final fruit set was still low (18% vs 14%) indicating that lack of pollination alone was insufficient to account for the low fruit set. The SI selections had significantly larger flower cups, pistil/petal size ratio, and more flowers/branch cross-sectional area suggesting that flower display may have an increased role in pollinator attraction in the SI selections. These results will be discussed in relation to 2 additional hypotheses: insufficient maternal resources and genetic factors resulting in pre- or post-zygotic selection.

323 REDUCING POLLEN LOAD MINIMIZES PISTILLATE FLOWER ABSCISSION AND IMPROVES COMMERCIAL ENGLISH WALNUT YIELDS UNDER FIELD CONDITIONS

G. S. Sibbett*, V. Polito, P. Catlin, G. Mc Granahan, J. Grant, K. Kelley, B. Olson, D. Ramos, University of California Cooperative Extension Office, Agricultural Building, County Civic Center, Visalia, CA 93291-4585.

In both laboratory and field experiments, excessive pollen has been found to be a major cause of pistillate flower abscission (PFA) and reduced yields of sensitive English Walnut cultivars (CVs) (especially "Serr"). In the field, PFA and reduced yields develop when substantial overlap of male and female walnut bloom occurs. PFA and poor yields can be further aggravated when pollenizing CV's have been included into an orchard to maximize pollen availability for the commercial CV Field

experiments, conducted in 1992 and 1993, demonstrated that mechanically shaking trees to remove male flowers pre-bloom from either pollenizer CV's or the main CV reduced pollen load, PFA, and substantially improved yields.

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SEED LENGTH AS A DEVELOPMENTAL MARKER FOR PREDICTING HARVEST DATE OF EARLY SEASON 'MAYFIRE' NECTARINES
Kevin R. Day*, Ted M. DeJong, and R. Scott Johnson, University of California Cooperative Extension, Ag Building, County Civic Center, Visalia, CA 93291-4584, and Department of Pomology, University of California, Davis, CA 95616.

Previous research with Mayfire nectarine demonstrated that seed length can be used as a developmental marker to predict the optimum date of girdling. Four years of study indicates that seed length also appears to be an effective physiologic marker for integrating early season heat accumulation. Seed length development was more highly correlated with heat accumulation ($r=0.936$) than with number of days after bloom ($r=0.699$). However, harvest date is more accurately predicted by number of days between 12mm seed length and harvest (30 ± 1) than by degree-days between 12mm seed length and harvest (337 ± 21).

170 ORAL SESSION 46 (Abstr. 325-330) Berries: Stress

325

FREEZE RESISTANCE OF STRAWBERRY FLOWERS IN THE PACIFIC NORTHWEST

Rita L. Hummel* and Patrick P. Moore, Washington State University Puyallup, Puyallup, WA 98371-4998

Freezing resistance of strawberry flowers from 'Benton', 'Honeoye', 'Hood', 'Puget Beauty', 'Rainier', 'Redcrest', 'Shuksan', 'Sumas', 'Totem', and WSU 1988 was measured in laboratory tests. Flowers with approximately 13 mm of pedicel attached were placed in test tubes containing 2 ml DI water. Tubes were immersed in an ethylene glycol bath, the temperature lowered to -1°C , and the flowers inoculated with crushed ice. The temperature was lowered to -1.5°C , held overnight then lowered 0.5°C every 2 hours. Samples were removed at 0.5°C intervals, thawed overnight at approximately 3°C and incubated 24 hours at room temperature and 100% RH. Freeze damage of styles and receptacle was determined by visual browning. Flower survival with no visible damage averaged 27% at -1.5 , 13% at -2.0 , 7% at -2.5 , and 4% at -3.0°C . There was clonal variation in flower survival: 56% of 'Hood' flowers survived -1.5 and 45% survived -2.0 while 5% of 'Redcrest' and 'Sumas' flowers survived these temperatures. Results seem to indicate that strawberry flower freeze resistance was due to freezing avoidance via supercooling.

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IMBIBITION IN SUGARS AND DEHYDRATION ALLOW STRAWBERRY PLANTLETS TO SURVIVE CRYOPRESERVATION

Manfredo J. Seufferheld* and Cecil Stushnoff, Department of Horticulture, Colorado State University, Fort Collins, CO 80523

Strawberry plantlets, regenerated from leaf disks, were used as a model system to study the effect of high concentrations of sugars and dehydration on survival during cryopreservation. After cold acclimation, plantlets imbibed for 3 days (one day each) in 0.5, 0.7 and 1.2 M sucrose and (1.0M sucrose + 0.2M raffinose) and desiccated to 25 % moisture (fwb) in alginate capsules consistently survived cryopreservation. Differential scanning calorimetry revealed only a very small exotherm between -20°C and -28°C during freezing; a glass transition at -50°C and a small melting event at -10°C during warming. Conversely, samples with the lowest survival rate, had a large nucleation exotherm at -30°C and a devitrification exotherm between -70 and -40°C . We conclude that imbibition with sugars, coupled with desiccation treatments, may be used to manipulate freeze tender tissues of strawberry to permit successful cryopreservation.

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LEAF WATER POTENTIAL, RELATIVE WATER CONTENT AND GAS EXCHANGE OF STRAWBERRY LEAVES IN RESPONSE TO WATER STRESS

Chuhe Chen*, J. Scott Cameron and Ann Marie VanDerZanden, Washington State University Research and Extension Unit, 1919 N.E. 78th St., Vancouver, WA 98665

Leaf water potential (LWP), relative water content (RWC), gas exchange rates and 4th-derivative spectra were measured in water-stressed and normally irrigated plank of Totem' strawberry (*Fragaria x ananassa*) grown in a growth chamber. CO_2 assimilation rate (A) dropped sharply when LWP decreased from -0.5 to -1.2 MPa and almost ceased as LWP fell below -1.5 MPa. There was a significant but more gradual decline of A as RWC decreased from 90% to 55%. An exponential relationship with A was observed across a wide range of LWP and RWC ($R^2 = 0.64, 0.86$, respectively). LWP was more closely related with transpiration and leaf and stomatal conductances than with A and water use efficiency. RWC was highly correlated with all gas exchange parameters.

Under moderate water stress, younger leaves maintain higher RWC and A than older leaves. There was no relationship between LWP and leaf age.

RWC and A were both negatively correlated with peak amplitudes of Ca 684 and Ca 697 and positively correlated with Ca 693 in their 4th-derivative spectra of chlorophyll. LWP had a negative correlation with Cb 640.

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EVALUATION OF g_s METHOD TO ASSESS HEAT AND DESICCATION INJURY AMONG *FRAGARIA* SPECIES

Suzanne S. McDonald*, Douglas D. Archbold, and Cheng Lailiang, Department of Horticulture and L.A., University of Kentucky, Lexington KY 40546-0091

The expression g_s , or tissue ionic conductance, was proposed to describe the efflux of ions from leaf disks (Whitlow *et al.*, 1992, Plant Physiology, 98:198-205). The objective of this study was to determine the effectiveness of the g_s method to screen germplasm for heat and desiccation tolerance using representative selections of 5 *Fragaria* species. Leaf disks were exposed to 4 levels of heat, 25, 35, 45, and 55 C, and 4 levels of desiccation. 60, 70, 80 and 100% relative water content (RWC). *F. virginiana glauca* was consistently ranked as the leakiest in all treatments including controls, with g_s values 70 to 100% higher than in the other species.

Temperatures of 25 to 45 C did not influence g_s over time. A temperature of 55 C was lethal to the tissue and, thus, the ion flux was initially very high but soon diminished. At 70% RWC *F. virginiana glauca* tissue was the leakiest, and *F. virginiana* and *F. vesca* tissues were somewhat leakier than those of *F. x ananassa* and *F. chiloensis*. Differences among species diminished with time in bathing solutions.

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DIFFERENTIAL THERMAL ANALYSIS OF RABBITEYE BLUEBERRIES

Gena R. Hughes* and Frank B. Matta, Department of Plant and Soil Sciences, Box 9555, Mississippi State, MS 39762.

Acclimation and cold hardiness of blueberry buds (*Vaccinium ashei* cv. Tifblue) were evaluated using differential thermal analysis (DTA) and tissue browning. Buds exhibited a single exotherm at -7°C October through December and at -11°C January through April. Low temperature exotherms (LTE) were not detected. Tissue browning test ratings indicated that ovary death occurred at -21°C .

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VACCINIUM ANGUSTIFOLIUM POPULATION VARIATION IN LOW-TEMPERATURE TOLERANCE AND FLOWERING CHARACTERISTICS

Paul E. Cappelletto* and Scott Dunham, Department of Plant, Soil, and Environmental Sciences, University of Maine, Orono, ME 04469

Commercial lowbush blueberry production involves management of what have long been considered highly diverse populations of naturally occurring clones. Wide phenotypic variation evident in fields has often been anecdotally equated with variation in yield, cultural requirements, etc., however this has not been tested rigorously. Interest in selection of clones with superior low-temperature tolerance prompted this study to estimate population-wide variation within the species. Thirty six clones of *Vaccinium angustifolium* exhibiting most of the typical phenotypic classes were selected from two commercial production fields in Maine. Plants were evaluated for low-temperature

tolerance of reproductive and vascular tissues on a monthly basis from November through April. In addition, variation in relative time of anthesis, flower structure, and floral low-temperature tolerance were determined. Results are discussed with respect to potential for selection of superior clones for both fruit production and ornamental use.

171 ORAL SESSION 47 (Abstr. 331-338) Vegetables: RFLP and RAPD Analysis

331 ORGANIZATION OF PROCESSING TOMATO GERMPLASM BASED ON RAPD BANDING PATTERNS.

James Nienhuis*, Joao B. dos Santos, Paul Skroch and Jan Tivang. Dept. of Horticulture, University of Wisconsin, Madison 53706
Genetic distance was calculated among 92 tomato, *Lycopersicon esculentum*, genotypes, which included open pollinated cultivars and commercial hybrids of both fresh market and processing types. Over 800 were screened, and 44 10-mer primers which had clear banding patterns and were polymorphic among cultivars were selected. From each of the primers an average of five polymorphic bands were classified for their presence or absence for each genotype. Genetic distance was calculated as the ratio of discordant to total bands scored. A multidimensional scaling (MDS) plot indicated that the processing cultivars, 'UC82' derivatives and fresh market types generally formed separate clusters. Within groups, genetic distance corresponded to known pedigree relationships. The genetic distance between duplicate samples of 10 genotypes ranged from 0.01 to 0.05. The results of this study indicated that RAPDs provide a high degree of resolution for estimating genetic relationships among tomato cultivars.

332 GENETIC SIMILARITIES AMONG CHINESE VEGETABLE BRASSICAS USING RANDOM AMPLIFIED POLYMORPHIC DNA MARKERS

Jianping Ren¹, Warren F. Lamboy*, Stephen Kresovich and James R. McFerson², USDA-ARS Plant Genetic Resources Unit, Cornell University, Geneva, NY 14456-0462, ³Institute of Vegetables and Flowers, Chinese Academy of Agricultural Sciences, Beijing 10081 China, and ⁴USDA-ARS Genetic Resources Conservation Unit, University of Georgia, Griffin, GA 30223-1797.

Fifty-two germplasm accessions of Chinese vegetable Brassicas were analyzed using 112 random amplified polymorphic DNA (RAPD) markers. The array of material examined spanned a wide range of morphological, geographic, and genetic diversity, and included 30 accessions of *Brassica rapa* (Chinese cabbage, pakchoi, turnip, broccoletto), 18 accessions of *B. juncea* (leaf, stem, and root mustards), and 4 accessions of *B. oleracea* ssp. *alboglabra* (Chinese kale). The RAPD markers unambiguously identified all 52 accessions. Net and Li genetic similarities were computed and used in UPGMA cluster analyses. Accessions and subspecies clustered into groups corresponding to the three species, but some accessions of some subspecies were most closely related to accessions belonging to another subspecies. Using genetic similarities, it was found that Chinese cabbage is more likely to have been produced by hybridization of turnip and pakchoi, than as a selection from either turnip or pakchoi alone. RAPD markers provide a fast, efficient technique for diversity assessment that complements methods currently in use in genetic resources collections.

333 RAPD MARKER FREQUENCY CHANGES IN TWO RED BEET POPULATIONS UNDERGOING RECURRENT SELECTION

K.A. Eagen* and I.L. Goldman, University of Wisconsin-Madison, Department of Horticulture, 1575 Linden Drive, Madison, WI 53706

Red beet contains betalain pigments recently adopted for use as natural food colorings. In an effort to develop beet populations with higher levels of betalain pigment, recurrent half-sib family selection for high pigment and both high and low solids was practiced in two populations for 7 cycles. PCR-based RAPD marker frequencies were assessed on genomic DNA samples isolated from 47 randomly-chosen individual plants from cycles 1, 3, and 6 in both populations. Number of PCR products per RAPD primer varied, with some yielding up to 5 scorable products. Chi-square and regression analyses were performed to determine presence/absence of linear trends in marker frequencies associated with selection. Significant linear trends in RAPD marker frequencies were detected for certain primers both between populations and among cycles. These data demonstrate changes in RAPD marker frequencies with selection and suggest linkage of RAPD markers to genes controlling pigment and solids in red beet.

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RESTRICTION FRAGMENT LENGTH POLYMORPHISM IN CARROT

Vivek Sampath* and Philipp Simon, USDA, ARS, Vegetable Crops Research, Dept. of Horticulture, University of Wisconsin-Madison, Madison, WI 53706

Studies of genetic variation at the DNA level in the genus *Daucus* have been very limited. Molecular markers based on restriction fragment length polymorphism (RFLP) have been shown to be highly useful and efficient gene markers in other plant species.

We have used a total of 20 carrot types (inbreds, varieties, species) for this study. Genomic DNA probes cloned in pGEM (Promega) plasmid of *Escherichia coli* were hybridized to DNA of these types digested with EcoRI and HindIII restriction enzymes. Based on 50 probe-enzyme combinations we have found RFLP variation to be extensive in *Daucus*, even among related cultivated genetic stocks. The implications of these results in the germplasm diversity in *Daucus* will be discussed.

Also, a genetic linkage map of carrot will be constructed. The map will be used to determine the genomic regions conditioning traits like root and core diameter, root length, and nematode resistance.

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ORGANIZATION OF ARTICHOKE, *CYNARA SCOLYMUS* L., BASED ON RAPD MOLECULAR MARKER BANDING PATTERNS.

Jan G. Tivang*, Neal DeVos, James Nienhuis, and Paul Skroch. Dept. of Horticulture, University of Wisconsin, Madison 53706. Elkhorn Research & Development, Castroville, CA, 95012.

Individual heads (capitula) from five discrete artichoke, *Cyara scolymus* L., populations were evaluated using RAPD markers. One vegetatively-propagated cultivar; Green Globe; two seed-propagated cultivars, Imperial Star and Big Heart XR-1; and two breeding populations were examined. Twenty-seven RAPD primers were scored yielding 2 to 16 polymorphic bands resulting in a total of 178 bands. Our objective was to determine if RAPD markers could be used to distinguish between and within populations. The genetic relationships among populations as well as among individuals within each population were estimated using the ratio of discordant to total bands scored. Data reduction (MDS) provided a plot indicating five clusters corresponding to the five populations. Confirmation of the presence of five discrete clusters was obtained by analysis of variance of the marker frequencies. The genetic diversity index (GDI) was calculated for each population as the pooled variance of band frequency for each population. The GDI values were highly correlated to the mean genetic distance within each population. The homogeneity of variance for the GDI values associated with each population were compared using the Siegel-Tukey test for homogeneity of spread.

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PHYLOGENETIC RELATIONSHIPS OF CELERY AND ITS WILD RELATIVES BASED ON RESTRICTION FRAGMENT LENGTH POLYMORPHISMS

Gordon M. Huestis* and Carlos F. Quiros, University of California, Davis, CA 95616

Phylogenetic relationships of seven *Apium* species, including three horticultural types of *A. graveolens*, were assayed for RFLPs using cDNA, chloroplast DNA, and rDNA probes. Most of the probes had been previously mapped in celery. The three horticultural types of *A. graveolens* were found to be less polymorphic than the wild species and in phylogenetic analysis they clustered together. The wild species formed a cluster on the dendrogram corresponding to their origin in the southern hemisphere. *A. nodiflorum*, a wild species from Ethiopia formed a branch on the phylogenetic tree apart from all other species. This, along with morphological considerations, suggests that *A. nodiflorum* should be reclassified outside the genus *Apium*.

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WHAT DOES IT TAKE TO GET A CULTIVATED BEAN?

E.M.K. Koinange, S.P. Singh, and P. Gepts*, Department of Agronomy and Range Science, University of California, Davis, CA 95616-8515 and Centro Internacional de Agricultura Tropical, Apartado aéreo 6713, Cali, Colombia

Cultivated plants and their wild progenitors show marked phenotypic differences regarding seed dormancy, the ability to disperse seeds, growth habit, phenology, photoperiod sensitivity, etc. We have used RFLP mapping to investigate the genetic control of these differences in a recombinant inbred population derived from a

cross between a snap bean and a wild bean. Traits were scored either at Davis or in Colombia. Our results suggest that the genetic control is relatively simple. In particular, most of the phenotypic variation (>60%) in the population could be accounted for in genetic terms for all but two traits. The genetic control of many traits involved genes with major effect (>30%). Some regions of the genome had major effects on several traits. Our results suggest that evolution can proceed by macromutations, domestication could have taken place fairly rapidly and introgression of additional genetic diversity could be introgressed relatively easily from wild beans into the cultivated bean gene pool.

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CONSTRUCTION OF A GENETIC LINKAGE MAP AND LOCATIONS OF COMMON BLIGHT RESISTANCE LOCI AND RUST ADULT RESISTANCE IN *PHASEOLUS VULGARIS* L USING RANDOM AMPLIFIED POLYMORPHIC DNA (RAPD) MARKERS

Geunhwa Jung¹*, Dermot P. Coyne¹, Paul W. Skroch², James Nienhuis², E. Arnaud-Santana¹, James Bokosi¹, and Shawn M. Kaeppler¹; ¹University of Nebraska, Lincoln, NE68583 and ²University of Wisconsin, Madison, WI53706

Common bacterial blight(CBB) and rust diseases, incited by the bacterial pathogen *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye (*Xcp*) and *Uromyces appendiculatus*, respectively, are important diseases of common beans (*Phaseolus vulgaris* L.). The objectives were to construct a molecular linkage map, to locate CBB resistances, rust resistances and leaf pubescence using RAPDs. Sixteen linkage groups with 22 unassigned markers were identified. 178 RAPD markers and 8 morphological markers were mapped in a Population of 70 RI lines. Regression analysis and interval mapping using MAPMAKER/QTL were used to identify genomic regions involved in the genetic control of the traits. One, two, and three putative QTLs were identified for seed, pod and leaf reactions. These regions accounted for 18%, 25%, and 35% of the phenotypic variation in CBB resistance. A chromosome region on linkage group 1 carried factors influencing all three traits. Rust resistance genes controlling the reactions on the primary and on the 4th trifoliate leaves (adult plant resistance) were located in linkage group 16. The genes for abaxial leaf pubescence was located on linkage group 9.

172 ORAL SESSION 48 (Abstr. 339-345) Vegetable Seeds and Seedlings

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ACC-DERIVED ETHYLENE PRODUCTION, A RAPID TEST FOR SEED VIGOR

Anwar A. Khan, New York State Agricultural Experiment Station, Cornell University, Geneva, NY 14456-0462

1-aminocyclopropane-1-carboxylic acid (ACC) was used to measure seed vigor of lettuce, cabbage, tomato, snap bean and sweet corn seeds. Accelerated aging at 40C and 93% RH over saturated solution of KH₂PO₄ and natural aging under ambient storage conditions (5-7C, 28 to 60% RH) were used to obtain seeds of differing vigor levels. Depending on the type of seeds, the amount of ACC needed for maximal ethylene production (saturating dose) ranged from 0.25 to 2mM. Seeds produced much larger amounts of ethylene in the presence than in absence of ACC, the ACC-derived ethylene was detected prior to germination, and ACC had no adverse effect on germination. ACC-derived ethylene production paralleled vigor loss as determined by percentage germination, mean germination time (for lettuce only) and seedling growth (for snap bean only). Second degree polynomial and logarithmic equations generated for the relationship of ACC- derived ethylene production to germination or growth parameters following seed aging, provided good to excellent fit. As a vigor test, the ACC-ethylene procedure has several advantages over the non-ACC ethylene procedure: it greatly improves the sensitivity of the test by enhancing ethylene production, it permits detection of small differences in vigor levels and it allows detection of ethylene prior to germination within a few hours of soaking.

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DETERMINATION OF WATER ACTIVITY AND MOISTURE CONTENT FROM PELLETED SEED

A. G. Taylor¹*, D. F. Grabe² and D. H. Paine¹ ¹Department of Horticultural Sciences, New York State Agricultural Experiment Station, Geneva, NY 14456 and ²Department of Crop and Soil Sciences, Oregon State University, Corvallis, OR 97331

The purpose of this study was to develop a procedure to determine seed moisture content from intact pelleted seeds. Samples of 'Sentinel' onion and 'Salinas' lettuce were pelleted by the following companies;

Asgrow, Germains (Seed Systems), Harris Moran, Incotec, Peto and Seed Dynamics. Physical characteristics of the various pellets were quantified including weight, volume and density. Measurements were made on intact pellets and densities ranged from 0.84 to 1.67 g/cc. Seed drying curves were obtained on the different pellets under controlled environmental conditions. Pellets were first equilibrated at 85% RH, and then dried at 25C and 18% RH. In general drying rates were similar among pellet types within crops. With regards to seed moisture content determination, neither the electronic moisture meter, based on measuring capacitance, nor oven methods were able to accurately measure seed moisture from intact pellets. Measurement of the head space RH from pre-equilibrated intact pellets (water activity) resulted in an accurate method to assess seed water status for all samples. The actual seed moisture content could be determined by using the moisture isotherms for each seed lot at a given temperature.

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EFFECTS OF HYDROPRIMING AND OSMOTIC PRIMING ON MUSKMELON SEED PERFORMANCE

Young Rog, Yeoung* and Dale O. Wilson, Dept. of Plant Science, University of Idaho, Moscow, ID 83843

Pregermination techniques of osmotic priming and hydropriming have been used to enhance seed performance on planting Osmotic priming and hydropriming method were compared on the basis of germination performance O₂, N₂ and air were supplied to 500 ml vessels containing seeds with distilled water or -1.31 MPa PEG solution for 10 days On removing seeds from vessels, seeds were dried back to original water content. There were no differences in total germination between osmotic priming and hydropriming treatments t50 was reduced dramatically from 112 to 32 hours, using hydropriming with air and N₂ supply for 1 day, compared to 70 hours of osmotic priming. Solute leakage from O₂ supply of both methods was higher than air or N₂ treatment, indicating the loss of membrane integrity Hydropriming with O₂ induced radicle emergence and loss of desiccation tolerance around 28 hours after treatment LEA protein levels were not changed in both treatments except for hydropriming with O₂. The timing of desiccation tolerance loss was correlated with that of degradation of LEA protein. O₂ supply caused the adverse effects on seed performance from both methods 1 day after treatment

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HEAT SHOCK AND SELECTIVE PRESSURE INCREASES *Cucumis sativus* SEEDLING TOLERANCE.

Paul H. Jennings, Department of Horticulture, Forestry and Recreation Resources, Kansas State University, Manhattan, KS 66506

We have previously shown that both temperature and chemical shocks are capable of inducing chilling tolerance in 24 h germinated cucumber seedlings. Using a heat shock temperature of 50°C, it has been demonstrated that a 2 min treatment is most effective in inducing chilling tolerance as measured by root survival growth. However the induced chilling tolerance is transient and disappears if the heat shocked seedlings are held at 25°C for 12 h before chilling at 2°C. Older seedlings (36 h of germination) are more sensitive to chilling but are still capable of chilling tolerance induction by heat shock. Using chilling as a selective pressure, it is possible to increase chilling tolerance of 24 h germinated seedlings.

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INCREASING CELL SIZE AND MEDIA PACKING ENHANCES THE GROWTH OF LETTUCE SEEDLINGS. TRANSPLANT QUALITY, AND FIELD PRODUCTION.

Silvana Nicola* and Daniel J. Cantliffe, Horticultural Sciences Department, University of Florida, Gainesville, FL 32611.

Cell size and media density can modify plant quality of greenhouse grown transplants through variation in light competition among plants, water and nutrient retention and root growth volumes required to fill the cells. Thus, 'South Bay' lettuce (*Lactuca sativa* L.) seedlings were grown in the greenhouse during different seasons to investigate the effect of different cell size and media packing density on transplant quality and yield for lettuce grown on sand and muck soils at different latitudes. Four Speedling flat cell sizes (882, 392, 242, 124 cells/flat) and two media packing densities (unpacked and packed - 1.5 times in weight) were tested in all the trials. Few seedling data parameters had an interaction between cell size and media density at transplanting. The larger cell size (242, 124 cells/flat) and greater media density led to increase leaf area, leaf length, shoot and total dry weight, RGR and LWR. Conversely, RWR and the root:shoot ratio had the opposite trend, reaching the greater values with smaller cell

size and less media density. High root growth can improve the pulling of the plants from the tray at transplanting and quicker establishment in the field. The treatments did not affect yield of plants grown on organic soil. When plants were grown on sandy soil head weights were greater from plants grown in 392, 242, or 124 cells/flat compared to 882 cells/flat.

344 PRETRANSPLANT NUTRIENT CONDITIONING: NITROGEN REGIMES FOR FLORIDA TOMATO TRANSPLANTS

Charles S. Vavrina*, University of Florida, Southwest Florida Research & Education Center, P.O. Drawer 5127, Immokalee, FL 33934, and George Hochmuth, University of Florida, Horticultural Sciences Department, Gainesville, FL 32611.

'Allstar' tomatoes raised from seed in Todd™ containerized transplant trays were treated with 1/4 strength Hoagland's solution modified to supply 0, 15, 30, 45, 60, or 75 mg·l⁻¹ N daily. Nutrient application was achieved via ebb and flow irrigation. N was supplied as ammonium nitrate. Tissue sample values for elements tested, excluding N, were essentially adequate for all treatments at transplanting (6 weeks after seeding). Visible transplant differences in the plant house did not translate to significant yield differences in the field when rates of 30 mg·l⁻¹ or greater were used in either spring or fall plantings in FL. A similar trial shipped to PA showed that 75 mg·l⁻¹ in the plant house resulted in the greatest early field yields, but 45 mg·l⁻¹ produced the greatest overall yield.

345 DIFFERENTIAL GROWTH INHIBITION OF BRASSICA SPECIES BY BROCCOLI RESIDUES

Jose R.A. Santos* and Daniel I. Leskovar, Texas Agricultural Experiment Station, Texas A&M University, Uvalde, TX 78801

Poor seedling emergence and stunted growth were observed in cauliflower (*Brassica oleracea* L., Botrytis group) and cabbage (*Brassica oleracea* L., Capitata group) crops when planted after three consecutive monocrops of broccoli (*Brassica oleracea* L., Italica group). This study was conducted to assess seed, seedling, and plant growth responses of broccoli, cabbage, and cauliflower to broccoli residue (leaves, stem + roots, and whole plant) extracts, broccoli residue incorporation, or soil previously cropped to broccoli. Osmotic potential, electrical conductivity, and pH of extracts were measured, rate (T_{50}) and total germination were determined. Filter-sterilized leaf extract delayed T_{50} (7.5 d) and reduced total germination (22%) of cauliflower compared to broccoli or cabbage. Similarly, plant height, shoot dry weight, and leaf area of cauliflower were significantly reduced when grown on broccoli soil in the greenhouse. Cabbage and cauliflower had low total marketable yields with more culled heads when grown in the field previously cropped to broccoli. Therefore, a potential growth inhibition of cabbage and cauliflower exists when following a continuous cropping of broccoli.

173 ORAL SESSION 49 (Abstr. 346-352) Floriculture: Postharvest

346 PRECURSORS OF SYSTEM II ETHYLENE SYNTHESIS IN SENESCING CARNATION PETALS

Pablo Gonzalez and Richard J. Glendon*, Department of Horticulture, Iowa State University, Ames, IA 50011-1100

Methionine (MET) is considered the first committed precursor of ethylene (C_2H_4), and the pathway has been established as MET → S-adenosylmethionine (SAM) → 1-aminocyclopropane-1-carboxylic acid (ACC) → C_2H_4 . It has been suggested that another pathway to C_2H_4 may exist, and this pathway has been labeled System II. Our objective was to evaluate several compounds as possible precursors of System II C_2H_4 production. 'White Sim' carnations were placed continuously in 20 mM solutions of MET, ACC, δ -aminolevulinic acid, glutamic acid, α -ketoglutarate, or homocysteine. Deionized water was the control. C_2H_4 production from the entire flower was measured, and ACC in the basal portion of the petals was quantified. Flowers treated with ACC exhibited the greatest C_2H_4 production and accumulation of ACC. Homocysteine

caused greater production of C_2H_4 and accumulated more ACC than MET and the other possible precursors. These results suggest that homocysteine may be involved in System II C_2H_4 production in senescing carnation petals.

347 ETHYLENE-INDUCED GENE EXPRESSION DURING FLOWER PETAL ABSCISSION OF ZONAL GERANIUMS

David G. Clark* and Kathleen B. Evensen, Department of Horticulture, The Pennsylvania State University, University Park, PA 16802

Ethylene-regulated gene expression is being studied in several plant systems, but the exact mechanism of ethylene action during plant development and senescence is poorly understood. When geranium (*Pelargonium Xhortorum*) flowers are exposed to 1 μ L of ethylene gas for 1 hour, petals begin to abscise within 60-90 minutes from the start of treatment. The rapidity of the response implies that it must be very direct. We now demonstrate that ethylene acts at the level of message accumulation. We have constructed a cDNA library from mRNA isolated from ethylene-treated geranium gynoecia. Ethylene-induced clones have been isolated by differential screening of this library with cDNA probes synthesized from ethylene-treated and untreated geranium gynoecia mRNA. Identification and characterization of these clones will be discussed.

348 SENESCENCE OF DAYLILY (HEMEROCALLIS) IS ASSOCIATED WITH EXPRESSION OF A MADS-BOX GENE

Nathan E. Lange¹*, Victoriano Valpuesta², Consuelo Guerrero², Miguel A. Botella², and Michael S. Reid¹, ¹Dept. of Environmental Horticulture, Univ. of California, Davis, CA 95616; ²Dept. of Biochemistry and Molecular Biology, Univ. of Malaga, Spain

As in many commercially important flowers, especially the monocotyledonous geophytes, senescence of the ephemeral daylily flower (*Heimerocallis*) does not involve ethylene. By differentially screening a cDNA library constructed from mRNA extracted from daylily petals in the earliest stages of senescence, clones were isolated whose transcription is up-regulated coordinately with the onset of senescence. One of these clones, sen12, was found to be a transcription factor. The deduced amino acid sequence of sen12 contains a MADS-box and an associated K-box similar to transcription factors suggested to control floral morphogenesis in a variety of different species. Northern blot hybridization showed sen12 to be highly upregulated before and during visible flower senescence. The expression of homologous genes during senescence of other flowers will be reported.

349 PROTEINS IN CHRYSANTHEMUM AS AN INDICATOR OF FLOWER LONGEVITY

Michelle H. Williams*, Terri A. Nell and James E. Barrett, Department of Environmental Horticulture, 1549 Fifield Hall, University of Florida, Gainesville, FL 32611

It is generally accepted that ethylene production is centrally located in petal senescence, however, non-climacteric flowers senesce irrespective of the presence of ethylene. The regulation of flower senescence may well be linked to protein synthesis. Our objective was to develop a simple tool which can be used in breeding programmes and/or the market place to determine potential longevity of a flower. Here, SDS-PAGE protein profiles of both potted and cut chrysanthemum flowers were determined from flowering to senescence. Generally, only minor changes in both protein content and the proportion of the major polypeptides were observed in the potted flowers. However, polypeptides at 40, 45 and 65 kDa increased during flower senescence and are of particular interest because they could be linked to flower longevity. The apparent stability of the proteins may contribute to the long postharvest life of the potted chrysanthemum.

350 VASE-LIFE DETERMINATION OF SIX SPECIALTY CUT FLOWER SPECIES

Paul B. Redman* and John M. Dole, Dept. of Horticulture and Landscape Architecture, Oklahoma State Univ., Stillwater, OK 74078.

The postharvest attributes of six specialty cut flower species were studied. First year results indicate that *Achillea filipendulina* 'Coronation Gold' had a vase-life of 10.7 days in deionized water (DI) and can be stored one week at 1.7°C and shipped for one day. *Buddleia davidii* (Butterfly Bush) had a vase life of 3.8 days in DI

water and tolerated two weeks of cold storage and two days of shipping. *Celosia plumosa* 'Forest Fire' (Plume Celosia) had a vase-life of 5.9 days in DI water and tolerated 2 days of shipping. *Cercis canadensis* (Redbud) had a vase-life of 9 days in DI water and tolerated one day of shipping. *Echinacea purpurea* 'Bright Star' (Purple Coneflower) had a vase-life of 4.6 days in DI water and tolerated 2 weeks of storage and five days of shipping. *Helianthus maximiliani* (Maximilian Sunflower) had a vase-life of 6.3 days in DI water and tolerated one week of storage. In addition, silver thiosulfate and 8-hydroxyquinoline citrate increased vase-life of *Buddleia davidii*, *Celosia plumosa*, *Echinacea purpurea*, and *Helianthus maximiliani*.

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POSTPRODUCTION EVALUATIONS ON FORCED *ASTILBE*

G.H. Pemberton*, Terril A. Nell, Ria T. Leonard, A.A. De Hertogh, Lena Gallitano and James E. Barrett, University of Florida, Gainesville, FL 32611 and North Carolina State University, Raleigh, NC 27695

Forced 'Bumalda' and 'Etna' *Astilbe* were evaluated for postproduction quality and longevity. Plants were sleeved, boxed and held at 9±2C for 3 days to simulate shipping at the following stages of floral development: tight bud (TB), 1-3 florets open, 25% florets open, 50% florets open, and 75% florets open. They were then placed at 21C and 14 µmol·m⁻²·s⁻¹ (12h daylength) until flower senescence. Percent of inflorescences flowering increased from 34% at TB stage to 94% when shipped with 25 % of the florets open. 'Etna' longevity increased from 3 days at TB stage to 12 days at 25% open stage. Optimum quality and longevity occurred when ≥ 25% of the florets were opened at shipping.

In a second experiment, 'Bumalda' and 'Etna' *Astilbe* were held at 18, 21 and 24C at irradiance levels of 7 or 14 µmol·m⁻²·s⁻¹ when 25% of the florets were open. At 18C, longevity increased under 14 µmol·m⁻²·s⁻¹ from 14 to 17 days. At 24C, longevity was only 10 days for both irradiance levels.

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POSTPRODUCTION OF NON-ROOTING ROOM BULBS

Terril A. Nell*, Ria T. Leonard, A.A. De Hertogh, Lena Gallitano and James E. Barret, University of Florida, Gainesville, FL 32611 and North Carolina State University, Raleigh, NC 27695

Postproduction evaluations of two cultivars each of Amaryllis (*Hippeastrum*), calla lily, *Freesia*, lily, and paperwhite *Narcissus* were conducted under postproduction temperatures of 18, 21 and 24C and irradiance levels of 7 or 14 µmol·m⁻²·s⁻¹. Amaryllis longevity ranged from 10 to 24 days, with an increase of 7 to 10 days at 18C. Excessive stem elongation occurred and was greatest at 24C. Calla lily longevity ranged from 33 to 68 days, with up to a 25-day increase at 18C and 14 µmol·m⁻²·s⁻¹. *Freesia* lasted 24 to 33 days with an increase of 6 to 9 days at 18C. Leaf yellowing and stalk elongation was a common problem of *Freesia*, especially at 24C. Lilies lasted 17 to 31 days, with an increase of 9 to 11 days at 18C. Asiatic lilies were superior to Oriental lilies. Paperwhite *Narcissus* lasted 13 to 27 days, increasing up to 10 days at 18C. Cultivar differences in longevity and quality were observed. Optimum postproduction conditions ranged from 18 to 21C at an irradiance of 14 µmol·m⁻²·s⁻¹ for best quality and longevity.

174 ORAL SESSION 50 (Abstr. 353-359) Woody Ornamentals: Culture/Growth/ Development

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CONTAINER SHAPE, SIZE, AND CUPRIC HYDROXIDE COATING AFFECT ROOT AND SHOOT GROWTH OF FICUS AND PEPPER TREES

Ursula K. Schuch and Dennis R. Pittenger*, Botany and Plant Sciences Department, University of California, Riverside, CA 92521

This study was designed to determine whether trees growing in tall, narrow containers versus regular containers of equal volume, or trees growing in containers coated with cupric hydroxide versus no coating would have a better quality root system, less circling

roots, and more biomass production. *Ficus* (*Ficus retusa* L. 'nitida') and pepper (*Schinus terebinthifolius* Raddi.) liners were grown for 6 months in the greenhouse in one-gal. containers. Cupric hydroxide coating prevented matting of roots on the side of the root ball in both species and root circling at the bottom of containers in *ficus*. Pepper trees growing in regular-shaped containers had a higher biomass production versus trees growing in tall containers. Subsequently, trees were transplanted to 3 or 5 gal. containers with shape or coating as described above. For pepper, cupric hydroxide coating versus no coating reduced circling and matting of roots, trees in regular versus tall containers had increased above ground biomass, and trees in 5-gal. versus 3-gal. containers grew more medium and small-sized roots and produced more total biomass.

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REDUCING ROOTING-OUT PROBLEMS IN POT-IN-POT PRODUCTION SYSTEMS

John M. Ruter, University of Georgia, Department of Horticulture, Coastal Plain Experiment Station, Tifton GA 31793-0748

A study was conducted with *Lagerstroemia indica* x *fauriei* 'Acoma' to evaluate methods for reducing rooting-out problems in a PIP production system. The products tested were Biobarrier™, a geotextile fabric impregnated with trifluralin; Root Control™ fabric bag material; and Spin Out™, a commercial formulation of copper hydroxide (7.1%) in latex paint. Biobarrier™ reduced plant height, shoot dry weight, percent root dry weight outside of the planted container and total biomass compared to the non-treated control. For the control, 7.1% of the total root dry weight was found between the holder pot and planted container compared to 0.2% for the Biobarrier™ treatment. When the holder pot and planted container or the planted container and Root Control™ fabric were both treated with Spin Out™, plant height and shoot dry weight were reduced. Spin Out™ reduced root circling on the sidewalls of the planted containers but not on the bottom of the containers. All treatments except the control reduced rooting-out to a degree that allowed for the manual harvesting of the planted container from the holder pot after seven months in the field.

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REDUCING MECHANICAL IMPEDANCE OF ROOTS IN COMPACTED SOILS INCREASES ROOT AND SHOOT GROWTH

Susan D. Day and Nina L. Bassuk*, Urban Horticulture Institute, Cornell University, 20 Plant Science Building, Ithaca, New York 14853

Four techniques for compaction amelioration were studied: 1) Vertical drainage panels; 2) vertical gravel-filled sump drains; 3) soil trenches filled with sandy loam; and 4) peat amended back fill. The control was backfilled with existing soil on the site. Vertical drainage mats and vertical gravel-filled sump drains were shown to increase O₂ in surrounding soil; however, all O₂ levels regardless of treatment were above what is considered limiting. Shoot and root growth of *Pyrus calleryana* 'Redspire' was greatest for treatments that alleviated mechanical impedance (soil trenches and amended back fill) and least for treatments that did not (controls and vertical drains). Vertical drainage mats which alleviated mechanical impedance to a lesser degree showed intermediate growth.

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COMPARISON OF REGIONAL CONSUMER PREFERENCES FOR PACKAGING OF NURSERY STOCK

Houchang, Khatamian* and Alan Stevens, Dept. of Horticulture, Forestry and Recreation Resources, Kansas State University, Manhattan, KS 66506.

During the Spring of 1992 a survey of over 2000 respondents was conducted as personal interviews at Flower/Garden Shows in Atlanta, Kansas City, Los Angeles, Philadelphia and Portland.

When asked how the plants you buy are packaged? Nine percent of the Los Angeles (LA) sample said they purchased trees as balled and burlapped (B & B) while over 40% of the consumers from the other regions purchased trees as B & B. Over 40% of all respondents purchased shrubs in "container".

When asked how would you like to have landscape plants packaged? While only 31% of the LA sample chose to purchase trees as B & B, over 70% of the consumers from other regions preferred to buy in a B & B form. More than 50% of all respondents also preferred to purchase trees in "Container". By a two to one margin consumers chose to purchase

ornamental shrubs in "Container". Regardless of the region of the country, "bare-root" and "plastic package" were least desired. About 1/2 of the respondents were couples, 80% owned their own homes, over 50% had an income of \$25,000 to \$75,000 and more than 75% did own plantings.

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ROOT AND SHOOT GROWTH PERIODICITY OF GREEN ASH, SCARLET OAK, TURKISH HAZELNUT AND TREE LILAC
J. Roger Harris, * Nina L. Bassuk, Richard W. Zobel and Thomas H. Whitlow
20 Plant Science, Cornell University, Ithaca, NY 14853

Root and shoot growth periodicity were determined for *Fraxinus pennsylvanica* Marsh. (green ash), *Quercus coccinea* Muenchh., *Corylus columna* L. (Turkish hazelnut) and *Syringa reticulata* (Blume) Hara 'Ivory Silk' (tree lilac) trees. Two methods for determining root growth periodicity using a rhizotron were evaluated. One method measured the extension rate of individual roots, and the second method measured change in root length density. A third method, using periodic counts of new roots present on minirhizotrons, was also evaluated. The root extension method showed the least variability among individual trees. Shoot growth began before or simultaneously with the beginning of root growth for all species with all root growth measurement methods. Species with similar shoot phenologies had similar root phenologies when root growth was measured by the root extension method, but not when root growth was measured by the other methods. All species had concurrent shoot and root growth, and no distinct alternating growth patterns were evident when root growth was measured with the root extension method. Alternating root and shoot growth was evident, however, when root growth was measured by the other methods.

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PHOTOSYNTHETIC RESPONSE OF SELECT RED MAPLE CULTIVARS TO LIGHT INTENSITY

Jeff L. Sibley*, D. Joseph Eakes, Charles H. Gilliam, and William A. Dozier, Jr., Department of Horticulture, Auburn University, Auburn University, AL 36849

Net photosynthesis (Pn), stomatal conductance (Cs), transpiration (Ts), and water use efficiency (WUE) were determined with a LICOR 6250 Portable Photosynthesis System for four cultivars of *Acer rubrum* L. under light intensities ranging from 300 to 1950 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{sec}^{-1}$ photosynthetically active radiation (PAR). As PAR increased, there was a linear relationship for Pn, Cs, and Ts for the cultivars 'Franksred' (Red Sunset TM) and 'October Glory'. In contrast, the cultivars 'Schlesingeri' and 'Northwood' had quadratic relationships for Pn and Cs as PAR increased. Ts was quadratic for 'Schlesingeri' and had a linear relationship for 'Northwood.' WUE was quadratic for each of the four cultivars.

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WOODY ORNAMENTAL TRIAL NETWORK IN QUEBEC

C. Richer-Leclerc(1) and J.-A. Rioux *(2). (1) Agriculture Canada, Ferme expérimentale, 801 route 344, L'Assomption, Qc, Canada, J0K 1G0. (2) Université Laval, Dép. de phytologie, Sainte-Foy, Qc, Canada, G1K 7P4. The "Réseau d'essais des plantes ligneuses ornementales du Québec" (REPLOQ) is a research project initiated in 1982 with the mandate to elaborate, develop and coordinate a cooperative research project to evaluate the winter hardiness of ornamental plants. Systematic evaluation trials provided information on growth potential and hardiness of woody trees and shrubs evaluated over a five year period in the principal growing regions of Québec. Zonal range covered was 2 to 5b in the Canadian system. Adequate field testing is critical for new introductions and, since 1984, more than 400 species and cultivars have been introduced in 8 evaluation sites. Results were published on several forms: technical factsheets provide cultural and production recommendations for the species and cultivar evaluated in each climatic zone. Propagation methods as well as their potential for ornamental purpose were described. In the 1984 plantation, *Malus baccata* and *Quercus macrocarpa* showed a similar potential for acclimation, but *Malus baccata* could be produced advantageously in any area, while the production potential of *Quercus macrocarpa* was enhanced by the summer heat of the warmest region. In this group of plants, *Acer saccharinum* was the species with the greatest number of plants suffering winter damage and could not be grown without risk anywhere in the area studied. *Acer platanoides* was severely damaged in the coldest of the eight evaluation sites and should not be cultivated there.

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RESEARCH PROGRESS OF IR-4 ORNAMENTAL PROGRAM

J. Ray Frank* and Daniel L. Kunkel, IR-4 Project, New Market, MD 21774 and Cook College, Rutgers University, P.O. Box 231, New Brunswick, N.J. 08903-0231.

Since the IR-4 Project for Ornamental Uses was initiated in 1977, over 13,500 research trials have been conducted. This effort has lead to over 3100 label-registrations for fungicides, herbicides,

insecticides, nematicides and growth regulators.

This cooperative program is conducted by Federal and State workers in conjunction with growers of nursery, floral crop and landscape plant materials.

175 ORAL SESSION 51 (Abstr. 360-366) Rose and Tree Fruits (Citrus and Papaya): Breeding and Genetics

360

ORIGIN, INHERITANCE, AND EFFECTS OF A DWARFING GENE FROM THE CITRUS ROOTSTOCK *PONCIRUS TRIFOLIATA* 'FLYING DRAGON'

Mikeal L. Roose*, Frank Suozhan Cheng, and Claire T. Federici, Department of Botany and Plant Sciences, University of California, Riverside, CA 92521

The 'Flying Dragon' cultivar of *Poncirus trifoliata* L. Raf. is a strongly dwarfing rootstock for *Citrus* cultivars, reducing canopy volume of 9 year-old 'Valencia' orange trees to 1/3 that of trees on standard rootstocks. Open-pollinated seed of 'Flying Dragon' was screened with isozyme markers to distinguish zygotic from nucellar (apomictic) seedlings. All zygotics had genotypes consistent with an origin by self-pollination. Zygotic seedlings were budded with 'Valencia' orange scion and planted in the field. Of 46 progeny evaluated as rootstocks, 35 produced small trees similar to those on nucellar 'Flying Dragon' and 11 produced large trees. This ratio is consistent with the 3:1 segregation expected for a single dominant gene. The dwarfing gene was closely linked, or pleiotropic with a gene causing curved thorns and stems. Several RAPD markers close to the dwarfing gene were identified with bulked segregant analysis. 'Flying Dragon' apparently originated as a mutation because it had an identical genotype to non-dwarfing strains of trifoliata orange at all 38 isozyme and RFLP markers tested.

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IN VITRO CITRUS BREEDING FOR SCION IMPROVEMENT

Francisco A.A. Mourão Fo*, Jude W. Grosser, and Frederick G. Gmitter Jr. Citrus Research and Education Center, University of Florida, Institute Food and Agricultural Sciences, Horticultural Sciences Department, 700 Experiment Station Road, Lake Alfred, FL 33850

Protoplast culture following polyethylene glycol (PEG)-induced fusion resulted in the regeneration of somatic hybrid plants from the following combinations: 'Succari' sweet orange (*C. sinensis* L. Osbeck) + 'Ponkan' mandarin (*C. reticulata* Blanco), 'Succari' sweet orange + 'Dancy' mandarin (*C. reticulata*), 'Succari' sweet orange + 'Page' tangelo [a sexual hybrid between 'Minneola' tangelo (*C. reticulata* X *C. paradisi* Mcf.) X 'Clementine' mandarin (*C. reticulata*)], 'Valencia' sweet orange (*C. sinensis*) + 'Page' tangelo. 'Succari' and 'Valencia' protoplasts were isolated from ovule-derived embryogenic cell suspension cultures and from seedling leaves for the other parents. Somatic hybrid plants were identified on the basis of leaf morphology and electrophoretic analysis of isozyme banding patterns. Root tip cell chromosome counting is being performed on all plants. Other putative somatic hybrids include: 'Succari' sweet orange + 'Minneola' tangelo; 'Succari' sweet orange + 'Murcott' tangos (*C. sinensis* X *C. reticulata*); 'Valencia' sweet orange + 'Murcott' tango; and 'Valencia' sweet orange + 'Dancy' mandarin. These plants may have direct cultivar potential, but their primary use will be for interploid hybridization with selected monoembryonic scions to produce improved seedless triploids.

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PRODUCTION OF SEVEN NEW INTERGENERIC SOMATIC HYBRIDS FOR CITRUS ROOTSTOCK IMPROVEMENT

Francisco A.A. Mourão Fo*, Jude W. Grosser and Frederick G. Gmitter Jr. Citrus Research and Education Center, University of Florida, Institute Food and Agricultural Sciences, Horticultural Sciences Department, 700 Experiment Station Road, Lake Alfred, FL 33850

Protoplast culture following polyethylene glycol (PEG)-induced fusion resulted in the regeneration of somatic hybrid plants from the following combinations: 'Succari' sweet orange (*C. sinensis* L. Osbeck) + *Severinia disticha*; 'Hamlin' sweet orange (*C. sinensis* + *S. disticha*; 'Valencia' sweet orange (*C. sinensis*) + *S. disticha*; 'Nova' tangelo (*C. reticulata* hybrid) + *S. disticha*; 'Succari' sweet orange + *S. buxifolia*; 'Nova' tangelo + *Citropsis gilletiana*; and 'Succari' sweet orange + *Atlantia ceylanica*. 'Succari', 'Hamlin', 'Valencia', and 'Nova' protoplasts were isolated from ovule-derived embryogenic callus and/or suspension cultures whereas protoplasts of *S. disticha*, *S. buxifolia*, *C. gilletiana*, and *A. ceylanica* were isolated from leaves of potted trees in a greenhouse. Plants were regenerated via somatic embryogenesis and somatic hybrids were

identified on the basis of leaf morphology. Electrophoretic analysis of isozyme banding patterns and root tip chromosome counts are being performed. Somatic hybrids with *S. disticha* are apparently weak whereas the other somatic hybrid plants with *S. buxifolia*, *C. gillettiana*, and *A. ceylanica* exhibit adequate vigor. These are more examples that the technique of protoplast fusion can be an important tool in overcoming barriers to hybridization of sexually incompatible species.

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INHERITANCE OF CITRUS NEMATODE RESISTANCE AND ITS LINKAGE WITH RAPD MARKERS IN CITRUS

Peng Ling*, Fred G. Gmitter Jr., Larry W. Duncan, and S. Y. Xiao, University of Florida, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, FL 33850

A family of 63 citrus intergenomic backcross hybrids was used for this study. The parents and hybrids were multiplied by rooted cuttings, with 6 uniform replicates selected per hybrid, and each plant was inoculated with citrus nematodes (*Tylenchulus semipenetrans*) 5 times over 2 mo. The number of nematode female larvae per gram of fine fresh root was determined 2 mo after the last inoculation. The phenotypic variation of the hybrids was continuous and wide-ranged, from 8.0 females·g⁻¹ of root tissue (resistant parent Swingle citrumelo=15.6) to 620.0 females·g⁻¹ of root tissue (susceptible parent LB 6-2=540.5). Bulk segregant analysis (BSA), using RAPD fragments, was conducted with 2 DNA bulks of individuals from the extremes of the phenotypic distribution. Three hundred twenty primers were screened and 5 were found to generate repeatedly single RAPD fragments specific to the resistant bulk. The segregation of resistance-associated fragments among the individuals was examined, and the linkage between these markers and potential nematode resistance loci was estimated.

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FIELD TEST OF VIRUS RESISTANCE IN TRANSGENIC PAPAYAS

S. Lius & R. Manshardt*, Horticulture, U. of Hawaii, Honolulu, HI 96822; D. Gonsalves, Plant Pathology, Cornell U., Geneva, NY 14456; M. Fitch, USDA/ARS, Hawaii Sugar Planters' Assn., Aiea, HI 96701; J. Slightom, The Upjohn Co., Kalamazoo, MI 49007; J. Sanford, Hort. Sci., Cornell U., Geneva, NY 14456

Twenty transgenic Carica papaya plants ('Sunset', R clone 55-1) carrying the coat protein gene (cp) of papaya ringspot virus (PRV) strain HA 5-1 have remained symptomless and ELISA-negative for 18 mo. after inoculation with Hawaiian PRV under field conditions. Control plants showed disease symptoms within 1 mo. after manual inoculation or within 4 mo. when aphid populations were the inoculum vectors. Trunk diameter was significantly greater in cp+ plants (14.3 cm) than in PRV-infected controls (9.3 cm). Fruit brix, plant morphology, and fertility of cp+ plants were all normal. Segregation analysis in R1 seedlings indicated that 55-1 contains a single transgenic insertion site. PRV resistance in R1 plants was linked with the cp gene, although in some progenies, up to 50% of cp+ plants developed mild PRV symptoms more than 3 mo. after inoculation. Preliminary tests suggest that this is not due to genesis of virulent mutant strains of PRV.

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BIOSYSTEMATICAL CLASSIFICATION OF GENUS ROSA USING ISOZYME POLYMORPHISMS

Young-ju Kim* and David H. Byrne, Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

Isozyme analysis has been used for cultivar identification, but little has been done with the genus Rosa. One hundred and sixty rose accessions (species, cultivars, and hybrids) were characterized for isozyme phenotypes using starch gel electrophoresis. Six enzyme systems were stained on three electrode buffer systems. ACP, MDH, and 6PGD were run on morpholine citrate (pH 6.1) and histidine (pH 5.7). PGI and PGM were run on histidine (pH 5.7) and lithium borate (pH 8.3), and SKDH was run on morpholine citrate (pH 6.1) and lithium borate (pH 8.3). The most variable isozymes were MDH and 6PGD. MDH and 6PGD revealed 10 and 9 bands, respectively. This study showed that isozyme variability exists in roses and can be useful in their classification into species groups.

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ROSA RESOURCES IN CHINA

Yan Ma* and Junyu Chen, Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133 and Department of Landscape Architecture, Beijing forestry University, Beijing, 100083, P.R.China

From 1986 through 1993 wild rose species were investigated throughout China to catalog and to characterize the rose germplasm resources in mainland China. Many of the 94 rose species and 144 rose varieties in China have not been extensively utilized. The basic features of Chinese rose species are as follows. (1) There are many valuable and rare Rosa species in China. These species are sources of many unique and outstanding characters such as intense fragrance, white and yellow flower color, recurrent flowering and resistance to stress. More than 80% of the rose species in China are native to only China. (2) Although most Rosa species are still in the wild state, a few species cultivated from very early time have many forms available. (3) The number of rose species gradually increases from Northeast to Southwest China. The distribution centers of Rosa species in China are Sichuan and Yunnan Provinces. Chinese rose species can be introduced and used directly in gardens, or in breeding programs to develop new roses.

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ORAL SESSION 52 (Abstr. 367-373) Fruits (Subtropical/Tropical): Postharvest

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QUALITY OF 'MANILA' MANGO AFTER HEAT TREATMENTS FOR FRUIT FLY DISINFESTATION.

Krista C. Shellie*, USDA-ARS 2301 S. International Blvd., Weslaco, TX 78596

'Manila' mangoes (*Mangifera indica*) were immersed in 46C water for 65 or 75 minutes, or exposed to 45, 50 or 52C moist, forced-air (MFA) for 240, 100, and 98 minutes, respectively. Mangoes exposed to 50 or 52C MFA had a significantly higher incidence of internal cavitation than mangoes exposed to 45C MFA; mangoes immersed in 46C water for 65 or 75 minutes, or control fruit. Shrink wrapped and nonshrink wrapped mangoes were exposed to 45C MFA for 240 minutes or 52C MFA for 98 minutes to evaluate whether the concentration of oxygen and carbon dioxide inside the fruit influenced cavitation development. Shrink wrapping per se had no significant effect on cavitation development. Mangoes heated in 45C MFA for 240 minutes, 52C MFA for 98 minutes, or 46C water for 65 minutes were hydrocooled in 23C water or air cooled at 23C to evaluate whether heat dose influenced cavitation development. Hydrocooling had no significant effect per se on cavitation development though it significantly reduced the heat dose. The above results suggest that tolerance of 'Manila' mango to disinfestation heat treatments is more influenced by a maximum flesh temperature threshold than the heating method, heat dose, or fruit internal atmosphere.

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TESTING SPRAY CHEMICALS FOR PHYTOTOXICITY ON CITRUS

L. Gene Albrigo* and Jude W. Grosser, Citrus Research and Education Center, University of Florida, 700 Experiment Station Road, Lake Alfred, FL 33850

In Florida, pesticides, nutritional and growth regulators are often sprayed in tank mixes to reduce sprayer use. Many individual spray components are phytotoxic and result in spray burns in combination or if applied with adjuvants. The toxicity level of standard spray materials is not known and new product testing for phytotoxicity is not routine. Three tests were developed to allow testing of cellular and whole fruit susceptibility to spray chemicals. Cell suspension cultures initiated from 'nucellar derived' embryonic callus of 'Hamlin' sweet orange were grown in log phase for 2 weeks with various levels of test chemicals. Fresh weight increase was measured. Peel disks of orange or grapefruit were grown for 4 weeks on solid media. Color changes and callus growth were used to evaluate phytotoxicity. Dilute sprays and droplet applications to on-tree-fruit were used to evaluate individual and combinations of chemicals with and without spray adjuvants. The 3 tests combined effectively demonstrated levels of phytotoxicity and are useful for testing new citrus production chemicals.

THE INFLUENCE OF PRE-AND POSTHARVEST TREATMENTS ON WASHINGTON NAVEL ORANGE

ABDEL HAMEED M.WASSEL AND MOAWAD ABDEL HAMEED EL MINIA. UNIV. FAC. OF AGRIC. EGYPT

Different treatments were carried out including that achieved in the modern packing houses which are established for preparing citrus fruits for export. Decay of Washington navel oranges was reduced due to spraying benlate at 500 and 750 ppm as a preharvest treatment. Fruits coated with thin film of wax containing benlate were less susceptible to decay than any other treatment including that carried out in the packing houses. On the other hand no adverse effect could be noticed for this treatment on the chemical properties of the fruits. Thereby, the disinfectant process which is followed by rinsing could be eliminated, consequently, raising the productive capacity of these packing houses.

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GRAPEFRUIT QUALITY IMPORTED INTO THE NETHERLANDS

Lawrence A. Risse* and Anton J. Bongers, USDA, ARS, European Marketing Research Center. 38 Marconistraat. 3029 AK Rotterdam, the Netherlands

Size 56 grapefruit (*Citrus paradisi* Macf.) were sampled biweekly from importers Rotterdam, the Netherlands from October 1992 through September 1993. For each sample, fruit size, weight, diameter, peel thickness, internal color, juice volume, total soluble solids (TSS), and total acid (TA) were measured for three cultivars 'Marsh White', 'Ruby Red' and 'Star Ruby' from 12 countries of origin. Florida fruit followed by Cuban fruit weighed more, had the thinnest peel, the most juice, the lowest TA, and the highest TSS/TA ratio for all three cultivars compared to most other origins. Spanish 'Ruby Red' and 'Star Ruby' fruit weighed the least and had the least amount of juice compared to other origins. Turkish fruit had the highest TA and the lowest TSS/TA ratio for all three cultivars. Israeli 'Marsh White' and 'Star Ruby' had the highest TSS.

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TRITERPENES IN GRAPEFRUIT EPICUTICULAR WAX

Harold E. Nordby* and Roy E. McDonald, USDA, ARS, SAA, Horticultural Research Laboratory, 2120 Camden Rd., Orlando, FL 32803

The purpose of this study was to identify compounds in the wax of fruit obtained from different canopy positions for possible relationships to chilling injury development. Both exterior and interior canopy grapefruit wax extracts were separated by thin layer chromatography into four lipid classes: alkanes, aldehydes, linear alcohols and triterpenes. The triterpene class consisted of three subclasses: triterpenols (TOH), triterpenones (TON) and triterpenol acetates (TAC). Each triterpene subclass was analyzed by gas chromatography and their component structures estimated by comparison of retention times with authentic standards. Derivatives were prepared for each subclass: TOH were oxidized to TON, TON were reduced to TOH, and TAC hydrolyzed to TOH. Structures were verified by gas chromatography-mass spectra of components and their derivatives as well as spectra of authentic standards and their derivatives. There was a higher level of TON in interior compared with exterior canopy fruit. The three major TON were α -amyrone, β -amyrone and friedelin. α -amyrone was also shown to be a major component of the wax of 'Valencia' orange, a fruit not subject to chilling injury when produced in Florida

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GRAPEFRUIT CANOPY POSITION AFFECTS CHILLING TOLERANCE AND FLAVEDO LIPID COMPOSITION

T.G. McCollum*, R.E. McDonald, and H.E. Nordby

USDA, ARS, SAA, USHRL, 2120 Camden Rd., Orlando, FL 32803

The objective of this work was to determine if lipid composition of grape fruit flavedo tissue differed with canopy position and if changes in flavedo lipid composition occurred during the development of chilling injury (CI). 'Marsh grapefruit' were harvested from interior (IN) and exterior (EX) canopy positions and stored at 5°C for up to 8 weeks. During storage, EX fruit developed severe CI, whereas IN fruit developed only trace CI. Electrolyte leakage from EX fruit flavedo increased during storage and significantly greater than from IN fruit

At the time of harvest, flavedo oleate and linoleate, on a $\mu\text{g} \%$ basis, were higher in IN than in EX fruit. During storage at 5°C, the amount of oleate in IN fruit flavedo decreased and was similar to EX fruit after 4 weeks at 5°C. The relative amount of flavedo linoleate decreased in IN fruit and increased in EX fruit during storage at 5°C and following 8 weeks at 5°C was higher in EX fruit than in IN fruit. At the time of harvest, total lipid P in flavedo was higher in IN fruit than in EX fruit; during storage the amount of flavedo lipid P in IN fruit decreased and was equivalent to EX fruit following 8 weeks at 5°C. Total sterols in flavedo did not differ with canopy position and remained constant during storage.

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MITOCHONDRIAL RESPIRATION OF 'HASS' AVOCADOS IN RESPONSE TO ELEVATED CO₂ CONCENTRATIONS

Diana Dostal Lange* and Adel A. Kader, Department of Pomology, University of California, Davis, CA 95616

Carbon dioxide-enriched atmospheres can be effective in the retardation of ripening and in the reduction of decay of horticultural commodities. However, concentrations in excess of the tolerance level may cause physiological damage. The goal of our research is to elucidate the specific regulatory mechanisms of CO₂ actions. Cytochrome oxidase (CytOx) *in vitro* activity in preclimacteric avocado fruit stored in air or 40% CO₂ + 12.6% O₂ was evaluated at 20°C. Activities were determined during treatment and also after a transfer to air. Fruit treated with 40% CO₂ + 12.6% O₂ had elevated CytOx *in vitro* activity when compared to air-stored fruit. Immunoblot analysis was performed to determine if the increase in CytOx activity could be due to an increase in enzyme concentration. The decline in respiration rate of CO₂-treated fruit was most likely due to the decrease in intracellular pH and its effect on the activities of important respiratory enzymes, including CytOx. The regulatory mechanisms of other mitochondrial respiratory enzymes in 'Hass' avocados exposed to elevated CO₂ atmospheres are also under investigation.

181 ORAL SESSION 53 (Abstr. 374-381) Education/Marketing

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PRACTICUM INSTRUCTION AND STUDENT LEARNING

Barbara Fails, Department of Horticulture, Michigan State University, East Lansing, MI 48824

Experiential learning is an integral component of successful career preparation for the horticulture industry. The limited-enrollment practicum course through Sparty's Flowers has been taught for 7 years, and accounts largely for the overall success of the retail floriculture program. Structure is built into the course by assigning weekly individual learning objectives and assignments. Students, in turn, develop their own action plans, upon which evaluation is based. Interactive group meetings replace formal lectures for more effective instructional delivery. Knowledge retention is enhanced as lessons are experienced, not only heard and read. Technical hands-on experiences of design, display, advertising, recordkeeping, sales, and merchandising sharpen abilities. Professional skills, such as time management, interpersonal communication, leadership, and creative problem solving are also developed and fostered by all members of the class. Practicum instruction, as an example of effective collaborative learning, allows a creative and realistic approach to teaching horticulture.

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SECOND-CHANCE TESTING IN HORTICULTURAL EDUCATION: A SECOND CHANCE TO LEARN

Sven E. Svenson, Fort Lauderdale Research and Education Center, University of Florida, 3205 College Avenue, Fort Lauderdale, FL 33314.

Students enrolled in three different horticulture courses were given traditional, in-class exams. After the in-class exams were completed, students were given another copy of the same exam to complete as a take-home test. Their final overall score was weighted as 65%

for the in-class exam, and 35% for the take-home. During the process of completing the take-home portion, students identified incorrect responses written on the in-class exam. The self-identified errors helped the students remember correct information on subsequent final exams. Students participating in the second-chance procedure scored over 5% higher on comprehensive final exams. The procedure has many variations, including written defenses of selected responses, but it requires the allocation of additional time by the instructor.

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COOPERATIVE LEARNING IN AN HERBACEOUS ORNAMENTAL PLANTS IDENTIFICATION CLASS

Douglas C. Needham* and Steven Dobbs, Oklahoma State University, Oklahoma Botanical Garden and Arboretum, Department of Horticulture and Landscape Architecture, 360 Agricultural Hall, Stillwater, OK 74078-0511.

Twenty-three students of HORT 2212: Herbaceous Ornamental Plants divided into five teams, each selecting one of the ground beds at the television studio gardens of *Oklahoma Gardening* to design with the aid of MacDraw II and Macintosh computers. The team approach promoted cooperative learning, where those who were skilled in design worked cooperatively with those individuals more skilled at developing the theme gardens' cultural pamphlets. This project encouraged individual students to develop various communication skills to support their team's thematic garden-visual, in the form of a CAD plot of the garden design; written, in the form of a garden pamphlet; and telecommunication, in the form of *Oklahoma Gardening* television segments.

The students and OBGA Ambassadors started the seeds and, then, planted the gardens, resulting in a very practical experience. This design and installation project not only prepared students for the cooperative efforts that they are likely to encounter in the ornamental horticulture and landscape design and maintenance industries, but also imparted pride in their work, which was viewed by over 150,000 television viewers and visitors weekly.

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EVOLUTION OF GREENHOUSE MANAGEMENT COURSES

Lois Berg Stack*, Dept. of Plant, Soil and Environmental Sciences, Univ. of Maine, Orono ME 04469-5722

Information presented in greenhouse management courses has changed in response to several factors. Increasingly, students must learn about:

- (1) new technologies such as the use of computers in crop management, and new techniques such as implementation of biological pest management;
- (2) regulations like the EPA/OSHA chemical safety laws;
- (3) experimental procedures, to be able to assess future technologies and techniques during their careers; and
- (4) professionalism (industry leadership, ability to work with the media, knowledge of how to impact law).

Changes in course content and procedures over time, and methods of teaching increased types and amounts of information, are discussed through results of a survey of current instructors of greenhouse management courses.

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ME, USE THE TEACHING PORTFOLIO? BUT I'M PREDOMINANTLY A RESEARCHER!

Dennis R. Decoteau* and T. Ross Wilkinson²

¹Department of Horticulture, Clemson University, Clemson, SC 29634

²College of Agricultural Sciences, Clemson University, Clemson, SC 29634

Public scrutiny about faculty time commitment have brought professor accountability to the front page of the daily newspapers. Many faculty in agricultural colleges at Land Grant Universities have split appointments in either research, teaching or extension. Effectiveness has been traditionally demonstrated in research by listing of publications, grants, graduate students, and presentations; but these measures are not necessarily appropriate measures for teaching. The need to better document teaching is imperative and a simple listing of classes taught and number of student contact hours can no longer be sole measures of teaching effectiveness. The Teaching Portfolio is a factual description of a professor's strengths and accomplishments. It includes documents and materials that collectively suggest the scope and quality of a professor's teaching performance. The Teaching Portfolio is an important tool for all

Land Grant faculty, regardless of their teaching responsibilities. As part of a ESCOP/ACOP Leadership Program at Clemson University, we have been reevaluating how university faculty are evaluated. We will discuss our experiences in introducing and using the Teaching Portfolio as part of a new evaluation process.

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CONSUMERS EVALUATE SERVICE QUALITY HIGHER FOR TEXAS FLORISTS THAN SUPERMARKET FLORAL DEPARTMENTS

Wayne A. Becker¹, Bridget K. Behe², Christine D. Townsend³, James L. Johnson¹, and Kerry K. Litzenberg⁴, ¹Dept. of Hort. Sciences, Texas A&M University: College Station, Texas 77843-2133; ²Dept. of Hort., Auburn University, Alabama 36849-5408; ³Dept. of Ag. Ed., Texas A&M University; ⁴Dept. of Ag. Econ., Texas A&M University.

A survey instrument developed to assess service quality in non-horticultural industries (SERVQUAL) was modified and administered to customers of eight florists and 22 supermarket floral departments in Texas. Sixty-six percent of 722 florist and 409 supermarket floral department responding customers had made a floral purchase within 12 weeks of the survey. Their responses were used in the service quality evaluation. Florists met consumer expectations better than supermarket floral departments each of five issues: tangibles, reliability, responsiveness, assurance, and empathy ($p=0.0001$). Florist customers perceived their retailer gave higher quality service than supermarket floral customers.

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THE SFASU ARBORETUM: A CONSERVATION STRATEGY FOR THE ENDANGERED PLANTS OF EAST TEXAS

D. L. Creech*, and J. Singhurst, Department of Agriculture, PO Box 13000, Stephen F. Austin State University, Nacogdoches, TX 75962

The Stephen F. Austin State University Arboretum occupies ten acres of campus property on the banks of LaNana creek, the stream that bisects the campus and the city of Nacogdoches, the oldest town in Texas. The mission statement of the Arboretum is to promote the conservation, selection and use of the native plants of east Texas. There are 19 species in east Texas that are either federally endangered, state endangered, or in danger of extirpation from the state. Many others face a serious decline in numbers as appropriate habitats diminish. A long-term project of *ex situ* and *in situ* conservation was initiated in 1992. Goals include: 1) acquire global position and vegetative analyses of endangered plant communities, 2) utilize ArcCAD® (a PC-GIS software) to archive a collection of maps, photographs, plant community data, and text, 3) maintain an *ex situ* collection of endangered plants from known provenances in the arboretum, and 4) reintroduction of species into appropriate protected habitats. The project involves the cooperation of several state and federal agencies and integrates the resources of a university horticulture program with the needs of endangered plant conservation.

182 ORAL SESSION 54 (Abstr. 382-389) Vegetables: Culture and Management II

382

PRECISION SEEDING STUDIES ON SNAP BEANS

H.C. Price* and A. G. Taylor, Department of Horticultural Sciences, New York State Agricultural Experiment Station, Geneva, NY 14456

Field studies were conducted in 1992 and 1993 to evaluate vacuum planters with respect to precision placement of seeds and to separately study plant spacing and emergence uniformity on stand establishment and yield. All studies were performed with Bush Blue Lake 47. In 1992, a cooperative study was conducted with the Experiment Station and ten growers in Upstate New York representing four makes of commercial planters. No planter was able to precision seed, and seedling emergence revealed a large tendency to clump plant, with less errors made in the form of misses or skips. In 1993, tractor planting speed was studied as a variable from 3.4 to 12.3 KPH (2.1 to 7.6 MPH) on spacing uniformity and yield. The average number of seedlings per meter of row was similar for all treatments, however, the variation in spacing between plants generally increased as planter speed increased. In research plots, in-row

spacing and emergence uniformity were studied. Plant population was held constant and three in-row spacings were developed (1 plant 5 cm apart, 2 plants 10 cm apart or 3 plants 15 cm apart). There were no differences in yield in this study. Daily emergence was recorded and seedlings were grouped into three categories based on their time to emergence (early, medium or late). Yield was more than twice as much from early than late emerging seedlings, while the medium group was intermediate with respect to yield.

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SPECIALTY/HEIRLOOM BEAN VARIETY EVALUATIONS IN THE LOWER SACRAMENTO VALLEY OF CALIFORNIA

Mike Murray* and Steve Temple, University of California, Cooperative Extension, P. O. Box 180, Colusa, CA, 95932

Significant industry interest exists for evaluating the lower Sacramento Valley as a production region for specialty dry beans. This interest is being driven by erratic or inconsistent production in the existing commercial production regions, mostly in the Pacific Northwest and the Mid-West regions. The environmental conditions in the Sacramento Valley are favorable for producing consistent yields of high-quality dry beans. Specialty beans are generally typified by limited markets and relatively high producer returns, and offers an attractive rotation crop for local growers.

Variety evaluations including many of the most popular or likely candidates for a local specialty bean industry were conducted in 1991 and 1993. Parameters evaluated included plant architecture, flowering dates, pod set and retention, maturity dates and seed yield. Additional qualitative evaluations to determine varietal quality were also conducted. Many varieties were identified that had both acceptable yield and seed quality potential.

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AGRONOMIC TRAITS OF 19 TEPARY BEAN LINES

Jan E. Paul Debaene* and Laren Robison, Department of Agronomy and Horticulture, 275 WIDB, Brigham Young University, Provo, UT 84602.

Tepary beans (*Phaseolus acutifolius* A. Gray) are native to north America and are considered drought and heat tolerant. Teparies are not commonly grown commercially, so little is known about their field performance. This study compared agronomic traits of 19 tepary bean lines to two pinto bean (*P. vulgaris*) varieties. The beans were evaluated under field conditions in a randomized complete block design with three replications. Traits examined included time to germinate, time to first trifoliate leaf, time to flower, height, seed protein content, and yield. Tepary yields ranged from 1593.0 to 656.4 kg/ha with three lines averaging 63.7 to 76.8% more than the average pinto bean yield. Tepary protein content ranged from 17.1 to 29.7% and averaged 24.7%. Tepary beans have great potential for adaptation to dry conditions while producing adequate yields and protein content.

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SUMMER FORCING AND HARVEST PRESSURES AFFECT ASPARAGUS SPEAR PRODUCTION IN COASTAL SOUTH CAROLINA

Robert J. Dufault, Clemson University's Coastal Research and Education Center, Charleston, SC 29414

The purpose of this 5-year study was to investigate the effects of different cutting pressures (3, 6, 9, or 12 spears/plant) on asparagus harvested in spring or forced in July or August. 'UC 157 F' seedlings were transplanted in 1987 and clear-cut harvested from 1989 to 1993. Forcing plots were not spring-harvested, but allowed to produce fern in spring. Summer spear production was forced by mowing all fern and stalks at ground level on the 1st day of each forcing month. Harvested spears were graded and harvesting ended if either 1) 80% of the plants within each plot reached cutting pressure treatment levels or 2) 30 harvests had elapsed. Yields in 1989 were highest and equivalent for the following: spring-harvested at 9 to 12 spears/plant, July-forced at 12 spears/plant, or August-forced at 9 spears/plant. In 1991, forcing in July at 12 spears/plant yielded more than harvesting in spring or August at all cutting pressures. In 1993, August forcing at 9 to 12 spears/plant produced the highest yields with significantly lower yields from July forcing at all cutting pressures. The 1993 spring yields were very poor due to plant death. Stand losses from 1988 to 1993 were 60%, 40%, and 30% in spring, July and August plots, respectively. Cumulative yields over the 5-year-period were greatest and equivalent for July forcing at 12 spears/plant and August forcing at 9 to 12 spears/plant.

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MECHANICAL ASPARAGUS HARVESTING STATUS--WORLDWIDE

Dale E. Marshall*, Agricultural Engineer, USDA-ARS, Fruit & Vegetable Harvesting, Farrall Hall, Mich. State Univ., E. Lansing, MI 48824

For over 86 years producers, processors, engineers, and equipment manufacturers have attempted to mechanize the harvest of asparagus. Over 60 U.S. patents have been issued. Probably the most sophisticated harvester tested was started in 1987 by Edgells Birdseye, Cowra, Australia. After

successful field tests of the 3-row, selective (fiber optic), harvester for flat-bed green asparagus used in canning, 3 more were built at a cost of \$US 4.5 million, and harvested 500 acres until 1991 when the company ceased canning. Recovery was 30 to 80% with 50% being typical. Wollogong University in Australia is now researching a selective (fiber optic), harvester for flat-bed green asparagus. It utilizes multiple side-by-side 3 in. wide by 24 in. dia. rubber gripper discs which rotate at ground speed. No harvester prototype has been commercially acceptable to the asparagus industry due to poor selectivity, low overall recovery (low yield relative to hand harvest), mechanical damage to spears, low field capacity per harvester, or overall harvesting costs that exceed those for hand harvesting. The reality may be that asparagus production will cease in the traditional geographical areas where growing costs and labor costs are high, although niche fresh markets may help some growers survive.

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FIELD PERFORMANCE COMPARISON OF TWO EXPERIMENTAL TRANSGENIC SUMMER SQUASH LINES AND THEIR PARENTAL LINE

Juan Pablo Arce-Ochoa*, Frank Dainello, and Leonard M. Pike. Texas Agricultural Extension Service, Texas A&M University, College Station, TX 77843-2133; Hector Quemada and David Drews. Asgrow Seed Company, P.O. Box 720094, McAllen, TX 78504.

Two of Asgrow's experimental virus resistant transgenic lines, XPH-1719 and XPH-1739, and their parental line, Pavo, a commercially grown virus susceptible hybrid, were tested for field performance at the Texas A&M University Experimental Farm in the summer of 1993. The two transgenic squash lines possessed the desired fruit and plant characteristics of Pavo plus resistance to ZYMV and WMV2 (XPH-1719), and resistance to ZYMV, WMV2 and CMV (XPH-1739). Under the conditions of this test it was determined that the two transgenic hybrids, were equally effective in producing high quality marketable fruits/ha with 89.64 % and 86.84 % respectively and marketable yields with 13,762 kg/ha and 16,525 kg/ha respectively. XPH-1719 and XPH-1739 also demonstrated their outstanding virus resistance by producing only 3.44% and 14.35% symptomatic plants/ha, and 0.00% and 7.17% infected fruits/ha respectively compared to 53.55% symptomatic Pavo plants/ha, and 25.73% infected Pavo fruits/ha.

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EFFECTS OF DEHAULMING ON CANOPY GROWTH AND TUBER YIELD OF 'YUKON GOLD'

James A. Okeyo* and Ronald D. Morse, Department of Horticulture Virginia Polytechnic Institute & State University, Blacksburg, VA 24061-0327

Seed tubers of 'Yukon Gold' (*Solanum tuberosum* L.) exhibit strong apical dominance, resulting in relatively poor stem emergence. Cutting seed tubers to overcome apical dominance in 'Yukon Gold' results in irregular, uneven stem emergence. In 1992 and 1993, experiments were conducted to evaluate the effects of dehauling (excising stems to ground level after field emergence) whole, cross- and longitudinal-cut seed tubers of 'Yukon Gold' on canopy growth and tuber yield. For all seed piece types, dehauling during the first week of field emergence produced uniform plant stands and increased yields of U.S. no. 1 tubers by 16 and 42% and large tubers (> 6.4 cm dia.) by 340 and 64% in 1992 and 1993, respectively. Our data indicate that tuber bulking rate was increased by dehauling. The possible causes and implications of increased tuber bulking rates in dehaulmed potato plants are discussed.

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EFFECT OF PLANTING DENSITY ON PRECOCIOUS PALM HEART YIELD OF PEJIBAYE IN HAWAII.

Charles R Clement and Richard M. Manshardt*, Dept Horticulture, University of Hawaii at Manoa, 3190 Maile Way, Honolulu, HI 96822

The pejibaye (*Bactris gasipaes*, Palmae) is being evaluated in Hawaii as a source of fresh hearts of palm. Nine open-pollinated progenies from the Benjamin Constant population of the Putumayo landrace are planted at three densities: 1.5 x 2 m (3333 plants/hectare); 1 x 2 m (5000 pl/ha, the commercial density in Costa Rica); 1 x 1.5 m (6666 pl/ha). Harvest started at 15 months after planting and four months later 25% of the plants had been harvested, with 25%, 30% and 21% at 3333, 5000, and 6666 pl/ha, respectively. Mean heart diameters were unaffected by density (mean±SD = 3.2±0.4 cm). Heart lengths were similar (24±5 cm, 23±6 cm, 26±5 cm, respectively), as were heart

weights (200±41 g, 187±44 g, 224±42 g, respectively). This relative uniformity was unexpected, as density effected all of these yield components in earlier experiments in Latin America. Potential yields were different (667±136 kg/ha, 835±221 kg/ha, 1491±275 kg/ha, respectively), and are comparable to yields reported from Costa Rica. Actual precocious yields, however, were not different (167 kg/ha, 278 kg/ha, 385 kg/ha, respectively).

183 ORAL SESSION 55 (Abstr. 390-397) Floriculture: Growth and Development

390

USE OF HARDENING TEMPERATURES ON SEVERAL SPECIES OF SEED-PROPAGATED HERBACEOUS PERENNIAL PLUGS PRIOR TO FREEZING. Beth E. Engle*, Arthur C. Cameron, Royal D. Heins, and William H. Carlson, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

Storage of perennial plugs at subfreezing temperatures could be a valuable production tool since plants could be removed over relatively long periods for forcing. Several species of seed-propagated perennial plugs were pretreated at 0 and 5C under continuous 50 $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ PPF for 0, 2, 4, or 8 weeks. After each pretreatment period, plugs were placed into 4-mil polyethylene bags that were then sealed and placed at -2.5C for 0, 2, or 6 weeks. Plugs were then removed from the bags and placed into a 24C greenhouse for two weeks under ambient light levels and daylength, after which time they were rated for percent survival and general regrowth quality. Regrowth was not influenced by pretreatment temperature. Regrowth of *Limonium dumosum* tatarica, and *Campanula carpatica* 'Blue Clips' following -2.5C storage was excellent with or without a pretreatment. Regrowth of *Achillea filipendulina* 'Cloth of Gold,' *Gaillardia grandiflora* 'Goblin,' and *Iberis sempervirens* 'Snowflake' was improved on plugs given the 0 or 5C pretreatment. *Hibiscus x hybrida* 'Disco Belle Mixed' regrowth was poor, regardless of pretreatment.

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THE INFLUENCE OF COLD DURING SEEDLING STAGE AND PHOTOPERIOD ON FORCING PERENNIALS FOR POT PLANTS. Allan M. Armitage* and Paul Thomas, Department of Horticulture, University of Georgia, Athens, GA 30602.

The influence of cooling, photoperiod and chemical branching on early spring flowering of perennial species was studied. Cooling was provided while plants were in plugs (128 plugs per tray) and dikegulac-sodium, a compound found to induce breaks in other species, was applied prior to, during and after cooling. Plants were cooled in insulated lighted coolers for 4, 8 or 12 weeks at 4C, and brought to a greenhouse with night temperatures between 8-12C. Long and short days were provided in the greenhouse after plants came out of the coolers. Little response to dikegulac occurred, however, *Campanula*, *Sedum*, *Leontopodium*, *Catananche*, *Aubrietia*, *Arabis*, *Gypsophila*, *Anchusa* and *Aquilegia* responded to cooling and photoperiodic treatment. Flowering and vegetative characteristics such as internode elongation and plant height responded to photoperiod and cooling but not all genera responded similarly. *Anchusa*, *Campanula*, *Aquilegia* and *Gypsophila* flowered significantly earlier under LD compared to SD. Twelve weeks of cooling resulted in flowering of all genera, however, some genera were equally responsive to shorter cooling times.

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CHILLING TEMPERATURE AND DURATION AFFECT FLOWERING AND BUD ABORTION OF 'PRIZE' AZALEAS William M. Womack*, Terril A. Nell, and James E. Barrett, Environmental Horticulture Department, University of Florida, Gainesville, FL 32611

Dormant-budded 'Prize' azaleas (*Rhododendron* sp.) were held at 2C, 7C, 13C, or 18C for 1, 2, 4, 6, 8, or 10 weeks then forced in walk-in growth chambers (29C day/24C night). Holding at 2C delayed flowering by 5-7 days over 7C and 13C. Plants held at 2C, 7C, or 13C for at least 4 weeks had approximately 50% buds showing color at marketability (8 open flowers). Plants held at 18C never exceeded 35% buds showing color at marketability. Increase in buds showing color was not apparent for plants were held at 7C, 13C, or 18C for more than 6 weeks; however, holding at 2C resulted

in increasing percentages of buds showing color for holding periods longer than 6 weeks. Plants chilled at 13C and 18C showed significant increases in bud abortion after 8 or 10 weeks of cooling with most plants never reaching marketability (8 open flowers). These plants also had an increased proliferation of bypass shoots during cooling and forcing over other treatments.

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ONE COOLER, SINGLE TEMPERATURE COOLING OF POTTED TULIPS

John M. Dole*, Department of Horticulture and Landscape Architecture, Oklahoma State University, Stillwater, OK 74078.

'Blenda', 'Leen v.d. Mark', 'Monte Carlo', 'Negritta' and 'Paul Richter' tulip (*Tulipa gesneriana*) bulbs received a total of 15 weeks of cold (5°C) with 0, 2, 4, 6, 8, 10, or 12 weeks applied to dry, unpotted bulbs. The bulbs were then planted, watered, and exposed to cold for the remainder of the 15 weeks. Bulbs receiving up to 10 weeks dry, unpotted cold showed no decrease in flowering percentage and plant quality when compared to bulbs receiving 15 weeks of moist, potted cold. For bulbs receiving 12 weeks of dry cold, flowering percentage was generally lower when compared with 0-10 weeks of dry cold and varied with the cultivar and the year, i.e. 63% of 'Paul Richter' and 100% of 'Negritta' bulbs receiving 12 weeks of dry cold flowered in year one; whereas, 95% of 'Paul Richter' and 70% of 'Negritta' bulbs flowered in year two. For all cultivars, bulbs receiving 12 weeks of dry cold had the shortest shoots at the end of the cooling treatment compared with the other treatments. While final height varied significantly with the cultivar in year two, differences were not commercially noticeable. Final height was not influenced in year one.

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HIGH-AND-LOW RESOLUTION ANALYSIS OF GROWTH IN SNAPDRAGON (*Antirrhinum majus* cv. Giant Tetra) AND ZINNIA (*Zinnia elegans* cv. Pompon) Will Neily*, Peter R. Hickleton, and David N. Kristie, Agriculture Canada, Kentville, N.S. B4N 1J5 and Acadia University, Biology Dept. Wolfville, N.S. B0P 1X0.

Stem elongation rates (SER) in snapdragon and zinnia were recorded in 3 DIF regimes (+5, -5, and 0; Daily average: 18C) using both high resolution (linear transducers), and low resolution techniques. Three developmental stages were chosen for study: Stage 1 was vegetative growth, preceding the formation of a flower bud. Stage 2 was the period from bud formation to preliminary expansion. Stage 3 was the period just before anthesis.

Low resolution measurements showed a decrease in snapdragon height in response to a negative DIF. A negative DIF was less effective in reducing zinnia height especially after the third developmental stage. Final plant height for both species was not affected by placing plants in the 3 DIF regimes for 1 week during the growth cycle.

Snapdragon and zinnia displayed unique diurnal SER patterns. Snapdragon showed a large peak in SER at the start of the dark period followed by a gradual decline. SER increased again during the light period. Most growth in vegetative zinnias occurred around the light/dark transition. This peak growth tended to shift to the night period as buds were formed and flowering proceeded. High resolution measurements revealed a reduction in SER for both species at negative DIF; greatest decreases occurred during the night.

DIF exerts an influence on diurnal SER in both snapdragon and zinnia, despite well defined differences in SER patterns. Negative DIF suppresses the SER of both species at all 3 developmental stages, but must be applied consistently in order to produce significant differences in final plant height.

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FAR-RED LIGHT REVERSES GROWTH-REGULATING ACTION OF NEGATIVE DIF

Glenn L. Roberts*, M.J. Tsujita and T. Blom, University of Guelph, Dept. of Horticultural Science, Guelph, Ontario, N1G2W1, Canada

Lilium hybrid 'Enchantment' bulbs were grown at a -4C or +4C DIF in growth chambers set at 100 $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ PPF, with or without one hour red or far-red light extensions to each end of an eight hour photoperiod. Far-red light extensions completely reversed the growth regulating effect of negative DIF temperatures. Negative DIF treated plants given far-red extensions were 43% taller than plants with no light extensions and 15% taller than plants given red light extensions. Prephotoperiod red or far-red extensions did not increase stem elongation over similar plants given no light extension, but postphotoperiod far-red extension stimulated stem elongation up to 52%. Red light extensions caused a less dramatic increase than far-red in some cases. The phenomenon is not photoperiodic since lengthening the photoperiod to ten hours caused no appreciable increase in stem elongation. Total 24 hour accumulated energy also proved not to be involved in the process.

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CALLA LILY VEGETATIVE & REPRODUCTIVE DEVELOPMENT PATTERNS

Ramona A. Reiser*, University of Florida GCREC, 5007 60 ST.E., Bradenton, FL 34203 and Robert W. Langhans, Cornell University, Dept. of Floriculture, 20 Plant Science, Ithaca, NY 14853.

The release of latent buds (adaptive reiteration) and aerial shoot architecture of the rhizomatous calla lily plant has been researched for pot production. Rhizome mapping has explicitly shown vegetative and floral bud positioning in relation to tissue growth and expansion. Floral initiation normally occurred only on the mother portion of rhizomes. Gibberellic acid (GA3) application enhanced this phenomenon and caused initiation on daughter ramets. Bud excision performed at planting through Day 16 microscopically revealed lack of floral initiation in dissected meristems prior to planting, transition by Day 4, elongation beginning at Day 8 and 'small to medium sized spadixes present by Day 12 and 16. Floral development was similar in treated and untreated primary buds, but delayed in secondary and tertiary buds with elongation occurring by Day 16. Pretreatment of GA3 prior to planting revealed spadix presence at Day 0. Floral development correlated with ramet size showed most flowers on largest ramets but formation on all sizes with GA3 treatment. GA3 also caused increased vegetative bud formation on rhizomes.

397
LIFE CYCLE AND FLORAL INITIATION OF ORNAMENTAL *ALLIUM* SPECIES

Rina Kamenetsky, Jacob Blaustein Inst. for Desert Research, Ben-Gurion University of the Negev, Sede Boker Campus 84993, Israel.

The annual life cycle and development of the monocarpic shoot of some ornamental *Allium* species from Central Asia and the Mediterranean area have been followed from the time of meristem dome initiation in the axil of a mother plant leaf, through formation of scale, leaf and flower primordia. There are three periods of meristem activity from apex initiation to flower formation. Detailed analysis of inflorescence development has been carried out by Scanning Electronic Microscope (SEM). The life span of the *Allium* monocarpic shoot can be as long as 18 months. Climatic variations between Central Asian and Mediterranean areas lead to differences in the time of leaf sprout and flowering of species from the same taxonomic group. The principal mechanism of floral initiation is similar for species from both areas.

Knowledge of the structure and development of the shoot will be useful for improvement of an optimal program of ornamental *Allium* cultivation.

401
LANDSCAPE PLANT EVALUATION PROGRAM AT THE TENNESSEE STATE UNIVERSITY NURSERY CROPS RESEARCH STATION

Phillip C. Flanagan*, Roger Sauve', Willard T. Witte', TSU-NCRS, Rt. 9 Box 538A, McMinnville, TN 37110; 'Dept. of Agricultural Sciences, Tennessee State University, Nashville, TN 37209-1561; 'Dept. of Ornamental Horticulture and Landscape Design, University of Tennessee, Knoxville, TN 37901-1071.

The Tennessee State University Nursery Crops Research Station is located at McMinnville in Middle Tennessee. This is a major nursery production area with a USDA Zone 6b climate and 134 cm mean annual rainfall.

Approximately 4 ha has been established, with drip irrigation, for comparative evaluation trials of *Acer*, *Cornus*, *Lagerstroemia*, *Quercus*, *Syringa* and *Ulmus*. Plants are being evaluated for: 1) landscape performance - growth, drought tolerance, heat/cold tolerance, 2) ornamental characteristics - bloom, leafcolor, fall color, shape, 3) resistance to disease and pests, and 4) adaptability for production under commercial conditions. Acquisition of plant materials began in 1992 with the collection and planting of more than 120 spp/cv of *Acer*. Plantings in 1994 consisted of *Cornus* = 100 spp/cv; *Lagerstroemia* = 70 spp/cv; *Quercus* = 90 spp/cv; *Syringa* = 50 spp/cv and *Ulmus* = 30 spp/cv.

The long term objective is the establishment of a comprehensive evaluation program for the nursery industry of Tennessee.

402
THE DEVELOPMENT OF A MANUAL OF SUSTAINABLE TREES AND SHRUBS FOR SOUTHERN NEW ENGLAND

Brian K. Maynard*, Richard A. Casagrand' and Roberta A. Clark', (1) Department of Plant Sciences, URI, Kingston, RI 02881 and (2) UMass Cooperative Extension, Barnstable County Office, Barnstable, MA 02630.

The development of a manual and database of recommended trees and shrubs was undertaken as a collaborative effort of the University of Rhode Island, University of Massachusetts Cooperative Extension and regional nursery stock producers. Initial selection was limited to species exhibiting few or no pest and disease problems, and without site requirements or other factors that could lead to higher maintenance in established landscapes. The preliminary list was reviewed by more than 30 representatives of regional arboreta, universities, growers, landscapers and arborists. In its third printing, the manual includes lists of recommended species, excluded species (with explanations), species for particular situations, and a guide to sustainable landscaping. The consortium brought together to create the manual is also developing a point-of-sale logo and poster to advertise recommended plant species and sustainable landscaping. This project has raised important issues about the interface between the industry and academia in promoting new and less readily available plants.

The database is maintained in FileMaker Pro (MAC), and will be made available in several DOS or MAC formats to those supplying a unformatted 3.5" DD or HD disk.

403
REGIONAL COMPARISONS OF NURSERY CONSUMER PREFERENCES ON PLANT VALUE CRITERIA AND STORE SERVICES

Alan Stevens* and Houchang Khatamian, Department of Horticulture, Forestry and Recreation Resources, Kansas State University, Manhattan, KS. 66506.

Correctly anticipating consumer preferences for goods and services can have a large impact on profitability. A survey to measure the influence of plant value and consumer preferences for store services was conducted at flower, lawn and garden shows in Los Angeles, Portland, Kansas City, Atlanta and Philadelphia. All five regional markets placed a greater importance on plant quality than on price or plant size. A trained professional sales staff and the availability of a large quantity and good selection of plant material were the highest rated store services in all of the markets. Offering free delivery had the lowest rating in every market. Having the store open on Sunday was more important in the markets on the west coast than in the Kansas City or east coast markets.

404
JOB ANALYSIS OF THE LANDSCAPE INDUSTRY IN ARIZONA.

Jimmy L. Tipton*, Department of Plant Science, University of Arizona, Tucson AZ 85721

The Arizona Certified Landscape Professional conducts educational programs and certification exams to increase the knowledge and skills of landscapers. To ensure that the program accurately reflects industry needs, we conducted a job analysis survey. Over 100 individuals in 48 landscape organizations responded. Two-thirds of the organizations were 'for profit' as opposed to municipal parks departments, school districts, and resorts. Half the 'for profit' organizations were small with gross receipts of less than \$100,000 annually. Forty percent of the 'for profit' organizations were

17 POSTER SESSION 1 (Abstr. 400-420A)
Education/Extension

400
SOFTWARE USAGE PATTERNS AND STUDY PREFERENCES IN THE EVALUATION OF A COMPUTER-BASED INTERACTIVE PROGRAM FOR WOODY LANDSCAPE PLANT INSTRUCTION

Christopher Lindsey*, Gate Kline, and Mark Zampardo, Department of Horticulture, University of Illinois, Urbana, IL 61801.

An interactive computer-based system was designed to improve student plant identification skills and knowledge of ornamental, cultural, and usage information in a woody landscape plant materials course. The program is written for use under ToolBook, a Microsoft Windows based program, and incorporates 256-color high-resolution images and text into a single interactive computer program. Features include: a slideshow that allows students to select which genera and plant characteristics are to be viewed and in what order with the option of an interactive quiz, seeing the names immediately, or after a delay; side by side comparison of any image or text selection; and encyclopedic entries, all with a user-defined path and pace of study.

The system is being used to study how students learn the information presented to them via computer technology and which program features are most useful for improving identification skills and knowledge of other plant features. The computer tracks and logs all activity by students on the system for analysis.

devoted exclusively to landscape maintenance, 28 percent were restricted to installation, and the remainder did both installation and maintenance. Size and nature ('for profit' or 'in house') of the organization had a significant impact on tasks and responsibilities of employees. These data will be used to modify the educational programs and certification exams to more closely resemble day-to-day activities among landscapers in Arizona.

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PB 016

A STUDY OF LANDSCAPE DESIGN PRINCIPLES USING VIDEO IMAGING TECHNIQUES

Dan T. Stearns* and Shirley M. Gryczuk, Department of Horticulture, Pennsylvania State University, University Park, PA 16802

Certain principles that appear in examples of successful design create the structure around which landscape design education is woven. Concepts of balance, contrast, rhythm, dominance, unity, and order must be understood before quality design is produced, but these concepts are often difficult to explain in a classroom situation. Commercially available video imaging software has proven to be a valuable tool in increasing student understanding of design principles. After scanning an actual site photograph, students add, delete, or modify plant materials and other amenities to strengthen the design principles as they relate to the specific site. Benefits of this method over traditional lecture or studio techniques include the ability to investigate a variety of sites and an increased ability to observe the inter-dependency of design principles. As modifications are made to strengthen one principle, the others are also affected in either a positive or negative manner.

406

PB 019

DEVELOPMENT OF AN INTEGRATED LOCATION AND INFORMATION DATABASE FOR TEACHING CAMPUS PLANT MATERIALS

Caula A. Beyl, Cathy Sabota*, and Gokul Ghale, Department of Plant and Soil Science, Alabama A&M University, Normal, AL 35762

In teaching a course in landscape plant materials, the landscape plants which exist on campus are an important and accessible resource. Management of location, health, and cultivar information is critical to optimizing this resource. As a classroom assignment, campus plant materials were inventoried, entered into FileMaker Pro 2.1, a database manager, characterized and assigned locations. The campus map was scanned using a Microtek ScanMaker IIXE and the image imported into MacDraw II. A symbol library, which included symbols for trees, shrubs, and groundcovers, was developed by scanning hand drawn images and then importing them into MacPaint. These bit-mapped images could then be duplicated as often as necessary and placed in appropriate locations on the campus map in MacDraw II. In this way, students are exposed not only to landscape plant materials but also to database managers and computer graphics capabilities. This approach also has the advantage that database information can be easily coordinated with physical location. plant materials can be sorted based on their characteristics, and information can be routinely and easily revised and updated.

407

PB 042

DESIGNING SYSTEMIC LEARNING IN HORTICULTURE

Ray D. William*, Anita Azarenko, Larry Lev, Jack Stang. Oregon State University, Corvallis, OR 97331

Gaps in learning occur when synthesis of factual information is assumed, delayed, or taken out of a realistic context. We are exploring wholes, simulations, case studies, natural resource issues, and interactive learning as ways to improve life-long inquiry and action. Realistic situations are described for student/adult participatory learning. Both group and individual learning are blended where facts are integrated at the "moment of learning" rather than a teaching moment. Teachers become coaches, facilitators, and providers of spontaneous lectures. Enthusiasm, participation and ownership by students and adults are spectacular. We've invented farmer-scientist focus sessions (FSFS) along with Rapid, iterative, interactive posters (RIIP). It's fun and seems to meet people's needs for complex topics and issues.

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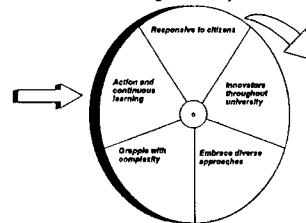
PB 045

WHAT WOULD A LEARNING UNIVERSITY LOOK LIKE?

Ray D. William*, Larry Lev, and R. N. Mallick, Dept. of Horticulture, Oregon State University, Corvallis, OR 97331.

In a world of rapid and unpredictable change, land grant universities must refocus their efforts on becoming more effective learning organizations. This poster addresses the critical opportunities, challenges, and tensions LGUs will face as they seek to enhance the continuous learning process and thereby flourish in the future.

What Would a Learning University Look Like?



409

PB 048

INCREASED ENROLLMENT AND MULTIPLE ACADEMIC PROGRAM SITES TYPIFY FLORIDA'S ENVIRONMENTAL HORTICULTURE UNDERGRADUATE PROGRAMS

Dennis B. McConnell* and George F. Fitzpatrick, Dept. Environmental Horticulture, University of Florida, Gainesville, FL 32611

Environmental Horticulture- undergraduate student enrollment at the University of Florida (UF) Gainesville campus decreased from 88 students in 1980/81 to 34 students in 1989/90. In 1983/84 a resident instruction program in Environmental Horticulture for placebound students was initiated by UF at the Ft. Lauderdale Research and Education Center. Enrollment rapidly increased from 6 students in 1984 to 67 students in 1989, with an average student credit load of 3.5 credits per semester. In 1990/91 increased student recruiting efforts were made with a common undergraduate handbook, recruiting brochure, and guides for academic program specializations developed to serve both locations. These efforts and others have increased enrollment at both sites. Currently there are 73 students in the Environmental Horticulture program at Gainesville and 87 students at Ft. Lauderdale. Students may begin their academic program at one location and transfer to the other site to complete their undergraduate requirements for the Bachelor of Science degree. A Bachelor of Science program in Environmental Horticulture will be initiated in the fall of 1994 in Milton, Florida, a small community in northwest Florida.

410

PB 051

SUPPORTING THE FARMER'S BOOKSHELF™ CROP INFORMATION SYSTEM ON TWO COMPUTER PLATFORMS

Kent D. Kobayashi* and H.C. Bittenbender, Department of Horticulture, University of Hawaii at Manoa, Honolulu, HI 96822 U.S.A.

Extension personnel and growers need up-to-date information on crops to make sound management decisions. The Farmer's Bookshelf™, a hypermedia information system based on the software HyperCard®, was developed for Macintosh® computers. Since clientele who use IBM-compatible computers could not use the Macintosh version of the Farmer's Bookshelf, we looked into several DOS/Windows™ hypermedia software. Spinnaker PLUS™ (Spinnaker Software Corp.) suited our needs, primarily because it required a minimum of reprogramming. PLUS (Macintosh) converted HyperCard files into PLUS (Macintosh) files. Some programming, fonts, and icons required modifications. PLUS (Macintosh) files were then edited using PLUS (Windows). Again, minor editing was necessary. Currently, the PLUS (Windows) files and a runtime version of PLUS (Windows) are distributed to clientele who use IBM-compatible computers. PLUS enables our supporting the Farmer's Bookshelf without having to develop a DOS or Windows version that requires completely new programming and extensive modifications. HyperCard files are readily converted to run under Windows, thus helping us to serve clientele who use either platform.

411

PB 054

ORIGIN OF HORTICULTURE IN SOUTHEAST ASIA AND THE DISPERSAL OF DOMESTICATED PLANTS TO THE PACIFIC ISLANDS

Robert F. Bevacqua*, Parks Dept., City & County of Honolulu, 650 S. King St., Honolulu, HI 96813

Navigators from Southeast Asia began voyages of discovery into the Pacific Ocean four thousand years ago that resulted in the dispersal of an assemblage of domesticated plants that has come to dominate horticulture in the world's tropical

regions. Archaeological, botanical, and linguistic evidence indicates the assemblage included coconut, banana, taro, yam, sugar cane, and other important food and fiber crops. An emerging view among scholars is that an origin of horticulture is associated with early Chinese civilization and that Southeast Asia was a center for the domestication of vegetatively propagated root, tuber, and fruit crops. This paper describes (1) an origin for horticulture in Southeast Asia, (2) the eastward dispersal of horticultural plants by voyagers, and (3) the impact of the introduction of horticulture on the natural environment of the Pacific Islands.

412 PB 057
MODEL FOOD WASTE PROCESSING PILOT FACILITY SITE TO DETERMINE MONITORING STANDARDS FOR THE COMMERCIAL OPERATION OF FOOD WASTE COMPOSTING SITES IN ILLINOIS. David Williams*, John Jaminski, University of Illinois, Department of a Horticulture, Urbana, IL 61801 and Pat Bumpus, Illinois Department of Energy and Natural Resources, Springfield, IL.

Food wastes were collected daily Monday through Saturday with approximately 25 tons of food waste delivered to the composting site each week. Collections sites included restaurants, super markets and a hospital. All food wastes were collected behind the counter to reduce paper and other extraneous materials. Food wastes were mixed with bulking agents in a ratio of 1 part leaves, 1 part woodchips to 1 part food waste by volume. Daily a bed of leaves and wood chips was prepared and covered with food waste, in turn the food wastes were capped with a mixture of wood chips and leaves to form a windrow. The windrow was turned three times a week with a scat style commercial compost turner. Oxygen content and temperature of the windrow were recorded daily. C:N ratio, pH, soluble nitrogen and volatile organic acids were determined monthly. At the end of the composting process, 90 days, Ni, Cd, Fe, Pb, Cr, Ar and Se levels in the compost were not present at toxic levels. Finished compost rested negative for salmonella and Fecal coliform pathogens.

413 PB 060
A PRINT-ON-DEMAND SYSTEM FOR PRODUCING EDUCATIONAL AND EXTENSION MATERIALS

James McConnell*, and Mari Marutani, College of Agriculture and Life Sciences, University of Guam, UOC Station, Mangilao, GU 96923

A Print-On-Demand (POD) System was developed for the rapid production of educational and extension materials such as fact-sheets. Information is stored in a final format on the computer and the number of copies of a specific publication can be printed as needed. The system greatly reduces the time to having the finished product and allows any number of publications to be printed. The printing cost ranges from \$.43 to \$.80 per page with a 300dpi color thermal wax printer.

Photo CDs and video capture images are the most common sources of color images used in the POD system. Photo CDs produce higher quality images but require time to process a film before images are used in the system. In live video capture, an image can be captured by a video camera, and sent to a computer for immediate production of a fact-sheet. Tape playback reduces the image quality compared to live video. Live video also gives the best feedback in determining whether the image shows the desired information. In general, the image is video captured at twice the needed size and reduced while increasing the resolution from 72 dpi to 130 dpi. This produces a better quality image. Other sources of pictures are flatbed scanners and slide scanners.

414 PB 033
STAMP OUT HORTICULTURE!

M. Elizabeth Conley*, Debra J. Schwarze, and David P. Lambe Departments of Horticulture, University of Nebraska, Lincoln, NE 68583-0724 and University of Minnesota, St. Paul, MN 55108-6007

Rubber stamps have traditionally been used in business to deliver visual or concise verbal messages. That tradition has changed as rubber stamps have also become an art form. Stamps are now available in virtually any horticultural design, including flowers, vegetables, fruits, trees, cacti, turf and as landscape design forms.

Stamps can be purchased at specialty stores, craft stores, book stores, kiosks at shopping malls, and from catalogs or they can be easily crafted from gum or rubber erasers. Two periodicals are available that describe stamping techniques and provide catalog sources: *Rubberstampmadness* (Corvallis, Oregon) and *Rubber Stampers World* (Placerville, California).

Using rubber stamps is fun and promotes creativity! Stamps can be used in a wide range of colors and they allow versatility in positioning, whether on paper or fabric. They are cost effective because they can be reused. Some suggested uses include enhancement of visual displays, personalization of mailings, and application for 4-H projects.

A list of selected references will be available.

415

PB 086

EFFECTIVENESS OF INTERACTIVE TELEVISION IN TEACHING MASTER GARDENERS

Lois Berg Stack*, Univ. of Maine Cooperative Extension, Orono ME 04469-5722

Master Gardener programs were conducted through 10 of Maine's 16 county offices in 1993. In an effort to reduce the number of identical presentations given by the limited number of instructors, 5 of the 10 sessions were conducted via interactive television (ITV), while the remaining 5 sessions were held locally. Participants (n=215) were surveyed about their learning experience in fall 1993. Data compare the local ITV audience vs. 7 distant audiences viewing sessions in real time vs. 2 audiences viewing taped sessions at a later date, on test scores of material presented, and on attitudes about the program. Data also summarize the types of projects on which Master Gardener volunteer hours were applied, and participants' attitudes about how volunteer programs could be made more effective.

416

PB 089

GOPHER THROUGH INTERNET TO CONSUMER HORTICULTURE INFORMATION

Paula Diane Relf*, Thomas McAnge, and Kathleen Dobbs, Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0327.

The Internet is a system of nearly 10,000 computer networks linked together in cooperative, non-centralized collaboration. There are more than a million host computers in 36 countries from universities, research groups, companies and government installations. GOPHER is a tool that allows someone to look for information by moving through menus in the Internet system until specific documents are identified that are of value to the researcher. A GOPHER Server has been established at VPI & SU for the Extension Service as follows:

Horticulture

Consumer Horticulture

(Includes the following topic areas: Environmental Issues; General Horticulture Information; Human Issues in Horticulture; Pest Management; Plant Fact Sheets; Virginia Gardener Extension Publications; Virginia Master Gardeners)

This information will be of value to educators, writers and private gardeners wanting current information on diverse consumer horticulture topics. The Human Issues in Horticulture information will be of particular value to researchers seeking information or collaborators in research related to the economic, environmental, psychological, physiological, social, cultural or aesthetic benefits of plants to people.

417

PB 092

BENNETT/JOHNSON PRAIRIE USER SURVEY

Anne M. Hanchek*, Dept. of Horticultural Science, University of Minnesota, St. Paul, MN 55108

Why do people visit the grounds of a botanical garden or arboretum? What draws them to that "experience of nature"? What can we do as horticulturists, landscape architects, and educators to make garden areas more appealing and fulfilling to visitors? The Prairie Interpretive Committee of the Minnesota Landscape Arboretum asked these questions in 1991 as it convened to analyze the current and future status of the Arboretum's Bennett/Johnson Prairie. To understand visitor usage and needs, Arboretum members were surveyed about frequency of visits, reasons for visiting, specific visitor services, and suggestions for improvements. Among the 151 responses, the major reasons for visiting were the pleasures of walking, observing, and being at peace. "Open", "wild," and "natural" were common key words. There was keen interest in native plants and their historical role as well. Sitting areas, maps, path markers, plant labels, and self-guided tours were the primary requests for improvement. A high percentage found the demonstration area interesting and useful. The Interpretive Committee used this research to guide the landscape architect, create a brochure, and develop an integrative master plan for the prairie area.

418

PB 095

WHOLE FARM CASE STUDIES OF HORTICULTURAL PRODUCERS IN WESTERN OREGON AND WASHINGTON

Helene Murray*, Richard P. Dick, Daniel Green-McGrath, and Larry S. Lev, *Minnesota Institute for Sustainable Agriculture, University of MN, 411 Borlaug Hall, St. Paul, MN 55108; and Oregon State University

Calls for increased farmer involvement in research and extension programs have been numerous and well supported. One approach to

integrate the collective knowledge and experience of scientists and farmers is through whole farm case studies (WFCS). An interdisciplinary team of 34 research and extension personnel at Oregon and Washington State Universities conducted WFCS of 16 vegetable and small fruit farms.

The WFCS process proved useful in developing an interdisciplinary team, and the vast majority of team members stated they would consider using the WFCS approach again; but the primary constraint cited was the amount of time required. Team members gained a better understanding of the complexity of farms and identified areas requiring further research. Farmers stated they enjoyed participating and discovered new information that will assist them in managing their farming systems. Farmer-developed innovations were identified that are useful to other farmers and to the research process.

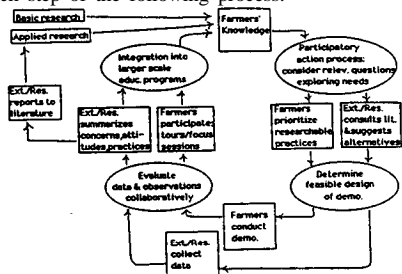
419 PB 098
MINNESOTA INSTITUTE FOR SUSTAINABLE AGRICULTURE: A PARTNERSHIP OF THE UNIVERSITY AND COMMUNITY GROUPS
Helene Murray*, Donald L. Wyse, and Emily E. Hoover Minnesota Institute for Sustainable Agriculture, University of MN. 411 Borlaug Hall, St. Paul, MN 55108

Minnesota has a long history of strong citizen involvement in environmental, community development, economic development, and human rights issues. Therefore, it is not surprising there are many individuals, organizations, communities, and educational institutions in Minnesota actively involved in the sustainable agriculture debate. The challenge we face is how to help these strong forces work in collaboration to solve rural problems.

In 1990 representatives of five community-based organizations and the U of M agreed to form the Minnesota Institute for Sustainable Agriculture (MISA) to be housed at the University and governed by a board of community and University representatives. The purpose of MISA is to bring farmers and other sustainable agriculture community interests together with University administrators, educators, researchers, and students in a cooperative effort to undertake innovative, agenda-setting programs that might not otherwise be pursued in the state.

420 PB 121
Farmer/Scientist Research In Participatory On-farm Trials
Stefan Seiter*, Ray William. John Luna, Dan McGrath, Tom Tenpas, Dept. of Horticulture, Oregon State University, Corvallis, Oregon.

A project was initiated in which a collaborative and mutual learning process was emphasized to (1) improve farmer designed research and to facilitate learning among farmers, research and extension, agribusiness and government agencies; (2) to enhance vegetable production systems by improving farm profitability, protecting water quality, and enhancing long-term soil productivity. The poster displays mutual learning that occurred during each step of the following process:



420A PB 135
A COMPARISON OF INTERACTIVE MULTIMEDIA INSTRUCTION WITH TRADITIONAL INSTRUCTION IN POST-SECONDARY PLANT MATERIALS COURSES
Mark Zampardo*, Gary Kling and Christopher Lindsey, Department of Horticulture, University of Illinois, Urbana, IL 61801.
An integrated teaching system was developed to enhance retention of course material covered in a woody landscape plants identification course. A Toolbook-based software program which incorporates high quality digital images and text in an interactive computer environment was tested on groups of randomly selected plant materials students. The objectives of the project were to: increase use of visual study techniques, facilitate individualized instruction, increase student access to information that is often not available in the classroom or from standard references, and enhance retention of course material. In alternating 4-week periods of time, one half of the students in the class had password access to the software. All students continued to receive traditional lecture and

laboratory presentations of the material. This study was conducted with a pretest-posttest control group experimental design. Students' written test scores, performance on identification exams and student opinions were compared between the two groups.

19 POSTER SESSION 2 (Abstr. 421-437) Nutrition

421 PB 124
GROWTH AND NUTRIENT DYNAMICS IN *Ilex crenata* THUNB. 'HELLERI' ACROSS AN ALUMINUM GRADIENT
F. Todd Lasseigne*, Timothy J. Smalley¹, Harry A. Mills¹, and William P. Miller² ¹Department of Horticulture, University of Georgia, Athens, GA 30602 ²Department of Crop and Soil Sciences, University of Georgia, Athens, GA 30602

Ilex crenata 'Helleri' (Helleri holly) can experience landscape establishment problems in the Southeast. Since aluminum toxicity is a major problem in acid soils of the Southeast, this experiment studied the effects of aluminum on Helleri holly grown in solution culture. A modified Hoagland's solution contained low phosphorus concentrations (32 µM), a 1:1 NH₄⁺:NO₃⁻ nitrogen ratio, and aluminum treatments consisting of 0, 222, 444, 889, and 1332 µM Al supplied at equal ratios from AlCl₃·6H₂O and Al₂(SO₄)₃·18H₂O. The MINTEQA2 (version 3.11) chemical speciation model was used to predict activity of ions in solution. Shoot growth and root length were not affected by aluminum after 12 weeks in solution culture. Total plant nutrient uptake was monitored weekly. Results indicate that Helleri holly does not take up aluminum ions even though NH₄⁺ is the preferred nitrogen source. Other studies have shown increased aluminum toxicity effects when NH₄⁺ is the preferred nitrogen source.

422 PB 127
PERFORMANCE OF NITRATE -N FERTILIZERS ON BERMUDA GRASS IN HUMID TROPICAL CONDITIONS
Mark D. Hamilton, Frank J. Cruz, and James McConnell*. College of Agriculture and Life Sciences, University of Guam, UOG Station, Mangilao, Guam, 96923.

The performance and leaching behavior of six nitrogen fertilizers on bermuda grass were studied under humid tropical conditions. The grass was established in 20 X 36 cm pots filled with 8 cm pea gravel and 28 cm of silica sand. Ammonium nitrate was applied to the turf at monthly rates between 0.25 and 6 lb/1000ft². Performance was gauged by clipping dry weights, image analysis for greenness, and visual ratings. Leachates were checked for nitrate levels. A rate of 2 lbs/1000ft² produced quality turf while yielding a minimum of nitrate leaching. Rates of 6 and 4 lb./1000ft²/mo. resulted in the highest readings without an increase in quality. Rates less than 2lb/1000ft² had leachate nitrate less than 9 ppm but produced turf of unacceptable quality.

Nutralene, Nitroform, sulfur coated urea, IBDU, and AN were applied at a rate of 2 lb./1000ft²/mo. The slow-release forms were applied as a 3 month dose. Performance was determined as above and nitrate leaching was monitored by weekly collections. Nutralene, SCU and Nitroform had peak nitrate levels 2 weeks after application, IBDU had peak nitrate levels after 4 weeks. Turf quality diminished at 6 weeks.

423 PB 130
FERTILIZER FORMULATIONS AFFECT LOWBUSH BLUEBERRY LEAF NUTRIENT CONCENTRATIONS
John M. Smagula* and David Yarrow, Department of Plant, Soil and Environmental Sciences, University of Maine, Orono, ME 04469-5722.

Experimental plots in a commercial lowbush blueberry (*Vaccinium angustifolium* Ait.) field deficient in N and P received preemergent 33.6 and 67.2 kg/ha rates of N (urea), P (23 % phosphoric acid), N+P (DAP), N+P+K (S-10-5) or N+P+K (fish hydrolysate, 2-4-2). A RCB design with eight replications of 12 treatments was used. Fertilizer containing N alone was as effective in raising N leaf concentrations, as those containing N and P. However, leaf phosphorus concentrations were raised more by fertilizer providing N and P than only P. Fish hydrolysate fertilizer was as effective as 5-10-5 in raising leaf N, P and K concentrations in prune and crop year leaf samples.

EVALUATION OF THE EFFECT OF SLOW-RELEASE FERTILIZERS ON TWO WOODY ORNAMENTAL PLANT GROWN IN CONTAINERS.

Saadia Triki, Isabelle Duchesne* and Jacques-André Rioux, Université Laval, Pav. Environtron, Sainte-Foy (Qc), G1K 7P4, Canada.

Slow-release fertilizers (SRF) are greatly used in container production in addition to an hebdomadal fertigation regime. For economic and environmental motives, growers wish to restrict fertigations. The objectives of this paper are to characterize the release patterns of several SRF and to determine the benefits of these fertilizers on the growth of selected woody ornamental plants. The SRF used in this study were: Osmocote®, Nutricote®, Polyon®, Nutralene® and Woodace®. The two first parts of the study were conducted in a greenhouse in Marsh 1993, with *Weigela florida* 'Rumba' in the first part and without plant in the second one. Fertilizers were top dressed according to a medium suggested concentration. The third part of this study was done in the field in June 1993, with the same fertilizers applied in three concentrations as follow: low suggested concentration (SC), 1.5X SC and 2X SC. Two species were tested in this part, *Weigela florida* 'Rumba' and *Spiraea bumalda* 'Goldflame'. Growth was measured by the height of the plant, the width of canopy and the dry mass of leaves, stems and roots. Samples leachate were collected weekly or monthly for greenhouse and field studies respectively. Leachates were analysed for their mineral content per dry mass of plant tissue and the results will be presented on the poster. In the third study, plants gave a comparable growth with the first and the third fertilizer concentrations.

FERTILIZATION AND IRRIGATION AFFECT AZALEA GROWTH

Thomas H. Yeager, Environmental Horticulture Department, IFAS, University of Florida, Gainesville, FL 32611

Multiple branched liners of 'Mrs. G. G. Gerbing' azaleas (*Rhododendron* L.) were greenhouse-grown for 16 weeks in 3-liter containers with a common nursery medium. The growth medium of each plant was amended with either 0.5, 1.5, or 2.5 g N from Osmocote 14N-6P-11.6K and irrigated with either 920 ml water twice a week or evapotranspiration (ET) plus 10%, 30%, or 50%. Shoot dry weights (35 and 35 g, respectively) for plants irrigated with ET plus 30% or 50% and fertilized with 1.5 g of N were larger than plants fertilized with 0.5 or 2.5 g N and irrigated with ET plus 10%, 30%, or 50%. Shoot dry weights of plants irrigated with ET plus 30% or 50% were similar to plants irrigated with 920 ml twice a week when plants received 1.5 g N. Plants that received 920 ml twice a week and 2.5 g N had larger shoot dry weights than plants irrigated with ET plus 10%, 30%, or 50% and fertilized with 2.5 g N. Shoot dry weights increased from 17 to 46 g for the 0.5 and 2.5 g N treatments, respectively, when plants were irrigated with 920 ml.

NITROGEN UPTAKE AND DISTRIBUTION IN RED OAKS AND RED MAPLES

Jill C. Larimer* and Dan Struve, Department of Horticulture, Ohio State University, Columbus, OH 43210

In the spring of 1993, red oaks (*Quercus rubra*) and 'Red Sunset' red maples (*Acer rubrum* cv. 'Red Sunset') were propagated from seed and microcuttings, respectfully. From June through October, plants were fertilized twice daily with 1.4 liters of fertilizer solution at concentrations of 0, 25, 50, 100, 200, or 400 ppm nitrogen from a 20-10-20 water soluble fertilizer. Destructive harvests were conducted six times at intervals from June through December. Leaf area, stem height, root length, root area, and dry weights of roots, stem, and leaves of harvested plants were measured and tissue nutrient concentration analyzed. Nutrient analyses of roots, stems, and leaves show seasonal distribution patterns of nitrogen. Dose- response patterns of fertilizer rate and growth were identified throughout the growing season.

INTERACTIONS BETWEEN POTASSIUM AND OTHER MINERAL ELEMENTS IN DROUGHT STRESSED AND NON-DROUGHT STRESSED *HIBISCUS SINENSIS* L. CV. LEPRECAUN

Jonathan N. Egilia, Fred T. Davies Jr.* and Sharon Duray, Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843

Hibiscus plants, were irrigated with full strength Hoagland's nutrient solution containing either 0.2, 5, or 10 mM potassium (K). After 72 days of K treatment, half of the plants at each K level were subjected to a 21-day slowly developing drought stress cycle and the other half were non-drought stressed (ND). Mid-day leaf water

potentials at day 21 was -1.5 to -1.6 MPa (DS), and -0.5 MPa (ND). Leaf K concentration increased with increasing K in nutrient solution for both DS and ND plants, but K was higher in DS than ND plants at 2.5 and 10 mM K. Of the macronutrient cations, only (Ca) was inversely correlated with nutrient solution K, in both DS and ND plants. Leaf concentrations of all the micronutrient cations increased with increasing K supply, regardless of drought stress. Potassium had significant positive correlation with total plant and leaf dry weight of DS, but not ND plants. Leaf stable carbon isotope composition ($\delta^{13}\text{C}$, an estimate of long term water-use efficiency), was positively correlated with N, Mg and Ca, and negatively correlated with K, iron (Fe), and K:total cation ratio regardless of drought stress. Both net photosynthesis and stomatal conductance were negatively correlated with N and Ca, but positively correlated with K, Fe and manganese in ND plants.

SPATIAL AND TEMPORAL VARIATION IN ORCHARD SOIL NITROGEN EXTRACTABILITY

Hilary J. Sampson* and S. A. Weinbaum, Department of Pomology, University of California, Davis, CA 95616

Extractable soil N may be leached below the plant rooting zone, and into the ground water. Orchards devoid of actively growing winter cover crops are subject to the greatest risk of NO_3^- leaching during tree dormancy in California. We examined the patterns of KCl extractable NH_4^+ and NO_3^- , and potentially mineralizable N (PMN) in the top 10 cm of soil across transects (60 samples, 150 m) in 3 almond orchard systems at 5 phenological stages in 1993. Extractable N was affected both spatially and temporally by management practices (e.g. herbicide or fertilizer application) and soil temperature. PMN did not exhibit local spatial patterns; geostatistical analysis revealed a trend across the transects indicating a larger scale of soil variation, possibly resulting from land leveling. The conventionally-managed orchard without a cover crop demonstrated higher levels of extractable NH_4^+ and NO_3^- in the top 10 cm in Feb. and Nov. 1993, compared with orchards managed with organic fertilizers and winter cover crops.

NET AMMONIUM UPTAKE BY ROOTS OF FIELD-GROWN PEACH TREES IS INVERSELY RELATED TO TREE NITROGEN STATUS.

F.J.A. Niederholzer* and S.A. Weinbaum, Pomology Department, University of California, Davis, CA 95616

The relationship between nitrogen (N) status and N uptake capacity has not been assessed in fruit trees. Determination of root uptake capacity by depletion of unlabeled N from external solution is less costly than methods using ^{15}N , but is reportedly not suited for excised root studies due to reductions in uptake rates with time (Pearcy, R.W. et al. (eds). 1989. Plant Physiological Ecology, p. 195. Chapman and Hall, New York.). We tested two hypotheses: 1) excised peach root NH_4^+ uptake rates are constant over several hours exposure to NH_4^+ solution and 2) excised peach root NH_4^+ uptake rates are negatively correlated with tree N status. Mature, N deficient, field grown 'O'Henry' trees on 'Lovell' peach (*Prunus persica* L. Batch.) rootstocks and growing in Winters, CA received $(\text{NH}_4)_2\text{SO}_4$ at a rate of 200 kg N/ha on September 29, 1993. An equal number of control trees received no N fertilizer. Foliar N deficiency symptoms of fertilized trees disappeared within 3 weeks of fertilization. On Nov. 9, 1993 (prior to leaf fall), excised roots were obtained from two fertilized and two unfertilized trees. Root NH_4^+ accumulation rates per unit root dry weight or root length were constant over 5 hours of exposure to 70 μM NH_4^+ (initial concentration) for both fertilized and unfertilized trees. Unfertilized tree root NH_4^+ uptake rates were significantly greater than those of fertilized trees on a root dry weight or length basis. Excised root NH_4^+ uptake may prove to be a sensitive index of fruit tree N status.

LEAF NITRATE AND AMMONIUM CONCENTRATIONS ARE MORE SENSITIVE INDICATORS OF SOIL N AVAILABILITY THAN TOTAL N IN NECTARINE.

Oswaldo A. Rubio, Patrick H. Brown and Steven A. Weinbaum, Department of Pomology, University of California Davis CA 95616.

Leaf N concentrations (% dry wt) appear relatively insensitive to high levels of applied fertilizer N (Weinbaum et al, HortTechnology 1992). This insensitivity may be attributable to growth dilution, lack of additional tree N uptake, a finite capacity of leaves to accumulate additional N or our inability to resolve a limited increment. Our objective was to assess the relative accumulation of mobile forms of N (NO_3^- , NH_4^+ and amino acids) relative to a total N over a range of fertilizer N application rates in 3 year old, field-grown "Fantasia" nectarine trees. Between 0 and 136 Kg N/ha/Yr we observed a linear relationship between N supply and all N fractions. Above 136 Kg N/ha/Yr leaf concentrations of amino acids and total N remained constant, but NO_3^- and NH_4^+ accumulation continued. These results suggest that leaf concentration of NO_3^- and NH_4^+ are more sensitive indicators of soil N availability and tree N uptake than was total leaf N concentration.

EFFECTS OF FALL APPLIED BORON ON ALMOND FRUIT SET.

Agnes M.S. Nvomora and Patrick H. Brown, University of California, Department of Pomology, Davis, CA 95616

Fruit set is a major determinant of nut productivity. Boron has been shown to have a significant influence on flowering and fruit set in a number of crops but less is reported on almond. This paper presents results of foliar application of a B commercial product, Solubor(20.5% B) at a rate of 1,2,3lb/100 gallons to 'Butte' and 'Mono' almond cultivars. Boron at 1 and 2lb increased fruit set in both open and hand pollinated trees by over 100% while 3lb was less effective. The resultant B concentration in flower buds was correlated to B concentration in flowers ($R^2=0.58$) and immature fruits ($R^2=0.6$) but not to summer and fall leaf, pistil, and pollen B concentration or fruit set.

432 PB 177

ADDITIONAL SYMPTOMS OF BORON DEFICIENCY IDENTIFIED IN ALMOND

Joseph H. Connell*, K. Uriu, W. Micke, J. Uyemoto, University of California Cooperative Extension, 2279 Del Oro Avenue Suite B, Oroville, CA 95965

Boron(B) deficiency in almond (*Prunus dulcis* Mill.) is characterized by leaf tip scorch, leaf drop, twig dieback, brown gummy areas in the endocarp, and embryo abortion followed by nut drop in May. Additional symptoms revealed by our work include failure of flowers to set nuts and lateral bud drop. Lack of production in part or in all of the free canopy causes spurs to elongate leading to a "willow twig" symptom on the small fruitwood. This can be confused with the nonproductive "bull" syndrome or with virus bud failure (ABFV or PRSV). Comparative leaf, pericarp, or kernel analysis in May gave a better indication of low B than did leaf analysis in August. In August, analyzing the hulls (mesocarp and exocarp) gave better separation between deficient and adequate trees than did leaf, kernel, or shell analysis. B critical levels for almond leaves should be re-evaluated since deficiency symptoms occur at currently accepted "adequate" levels.

433 PB 180

ASSESSMENT OF NITROGEN DEMAND IN MATURE, ALTERNATE BEARING PISTACHIO TREES

Richard C. Rosecrance,* Steve A. Weinbaum, and Patrick H. Brown, Department of Pomology, University of California, Davis, Davis, CA 95616

Contributions of nitrogen (N) fertilizer applications to nitrate pollution of groundwater is an increasing public health concern. In an effort to improve N fertilizer efficiency, a study was initiated to determine periods of tree N demand in mature, alternate bearing pistachio trees. Seasonal patterns of nitrogen accumulation in the branches (i.e. fruit, current year wood, one year old wood, and leaves) and roots were monitored monthly.

Branches from heavily fruiting trees contained almost six times more nitrogen than branches from light fruiting trees by September; a result of the large amount of N accumulated in the fruit. Nitrogen accumulated in the branches during the Spring growth flush and nut fill periods in both heavy and light fruiting trees. Root nitrate and total N concentrations, however, peaked during the Spring growth flush and subsequently decreased during nut fill. The relationship between tree N demand and the capacity for N uptake is discussed.

434 PB 203

INFLUENCE OF XYLEM FLUID CHEMISTRY OF PRUNUS SPP. ON THE ABUNDANCE AND PERFORMANCE OF ADULT HOMALODISCA COAGULATA.

Peter C. Andersen, Brent V. Brodbeck and Russell F. Mizell, III, Univ. of Florida, NFREC-Monticello, Rt. 4, Box 4092, Monticello, FL 32344

The xylophagous leafhopper *Homalodisca coagulata* Say is an important vector of diseases caused by the bacterium, *Xylella fastidiosa* (e.g., Pierce's disease, phony peach disease, plum leaf scald, etc.). Neither leafhoppers or *X. fastidiosa* can be controlled by chemical sprays. For many plant species there is no resistant germplasm. *H. coagulata* is highly polyphagous, and within *Prunus* spp. host preference ranges from moderate (plum) to low (peach). The abundance, feeding and performance of *H. coagulata* on many unrelated plant species have been previously correlated with the amino acid profile, and particularly the amides in xylem fluid. We tested

Prunus scion/rootstock combinations, which provided for a range of xylem fluid chemistry, on the behavior (abundance, feeding) and performance (survivorship, fecundity, body weight and body composition) of *H. coagulata*. Leafhopper abundance on various rootstock/scion combinations was determined seasonally. During the period of peak abundance (June 14 to 30) feeding rates and performance indices were determined. Leafhopper abundance and feeding increased with an increased concentration of amino acids. Abundance and feeding rate were most highly correlated with the amides in xylem fluid; performance indices were influenced by the amides and certain essential amino acids. Lower consumption rates decreased survivorship, reduced body dry weight and the carbon concentration of surviving insects.

435 PB 206

EFFECT OF MYCORRHIZAL FUNGI AND PHOSPHORUS ON GROWTH AND NUTRIENT UPTAKE OF NEEM TREE SEEDLINGS (*AZADIRACHTA INDICA* A. JUSS)

Lop Phavaphutanon* and Fred T. Davies, Jr., Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

Growth and nutrient content of neem tree seedlings (*Azadirachta indica* A. Juss) were studied in response to the mycorrhizal fungi *Glomus intraradices* Schenck & Smith and Long Ashton Nutrient Solution (LANS) modified to supply phosphorus (P) at 0.65 and 1.30 mM P. Three months after inoculation, an extensive mycorrhizal colonization was observed in mycorrhizal plants at both P levels. Shoot growth of mycorrhizal plants was similar at both P levels while the growth of nonmycorrhizal plants increased with increasing P supply. Mycorrhizal plants had greater leaf area, shoot dry weight and root to shoot ratio than nonmycorrhizal plants at the same P level. The length of nonsuberized roots increased with increasing P supply regardless of mycorrhizal colonization while the length of suberized roots was significantly increased by mycorrhiza. Mycorrhiza altered dry mass partitioning to root systems resulting in greater length and dry weight of suberized roots in mycorrhizal plants. Mycorrhiza also improved nitrogen, phosphorus, calcium and sulfur uptake but did not affect micronutrient uptake, except for enhancing boron.

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VARIATION IN N_2 FIXATION AND GROWTH AMONG HALF-SIB FAMILIES OF *MAACKIA AMURENSIS*

J.Giridhar B. Pai* and William R. Graves, Department of Horticulture, Iowa State University, Ames, IA 50011-1100

Maackia amurensis Rupr. & Maxim. associates with N_2 -fixing rhizobia, but variation in N_2 fixation among genotypes of this species is not known. We determined the effect of N_2 fixation on growth of plants from seven half-sib families known to differ in seed mass and seedling growth when provided N. Seedlings were grown in Leonard jars for 12 weeks in a greenhouse. Mass of control plants provided N and nodule mass on plants inoculated with rhizobia (USDA 4349) and not provided N differed among families. Among plants not provided N, inoculation did not increase dry matter but did reduce chlorosis. Therefore, plant N content also will be discussed as an indicator of efficiency of N_2 fixation. Results indicate N_2 fixation improves plant quality in low-N soils but will not eliminate the need for N applications during seedling production.

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EFFECT OF SOIL FUMIGATION WITH METHYL BROMIDE ON MINERAL NUTRITION OF STRAWBERRY

*Ragab, M.E. & Okasha, Kh. A.

Strawberry Improvement Center, Faculty of Agric. Am Shams Univ, Cairo, Egypt. FAX 5721628

This study was earned out on strawberry (*Fragaria Xananassa*, Duch.) during the tow successive season of 1988/1989 and 1989/1990, at the strawberry Improvement Center Experimental Farm at Omm saber, south Tahreer, El Behira Governorate. The objective of this work was to study the effect of strawberry cultivar Douglas A split-plot design with four replicates was adopted. The results indicated a substantial increase in the content of the available macro and micro nutrients in the fumigated soils compared to the non fumigated ones. A significant increase in the number of leaves per plant, fresh and dry weight, early and total yield per plant was recorded. Fumigation accompanied by fertilization increased the available content (N,P and K and (Fe, Mn, Zn, and Cu) in the soil in the both growing seasons compared to fumigated only or the control. Plants grown in the fumigated fertilized plots contained the highest amount of macro and macro nutrients in both the growing seasons. Fumigated non fertilized plots had the highest amount of available P and K than all other treatment. The maximum early and total yield per plant was obtained from the fumigated non fertilized plots.

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PB 215

RISK OF GENE MUTATION IN MAJOR CROPS

Bruce M. Pollock, Science Mediation Service, 5000 Butte St.
#28, Boulder, CO 80301-2236

The book, *Agricultural Biotechnology: Issues and Choices Information for decision Makers*, from USDA and Land Grant Colleges discusses risk evaluation for the use of legislators concerned with public policy. However, that discussion is entirely theoretical. The 1970 epidemic of Southern Corn Leaf Blight caused by the pleiotropic gene for Cytoplasmic Male Sterility provides material to use in real-world risk evaluation for biotechnology. Approximately 1×10^{12} corn seeds are planted annually in the US. Assuming a mutation rate of 1×10^{-6} , then 1×10^6 mutations can be expected annually. The poster will evaluate the importance of this number using assumptions based on fold-increase during seed production. Unfortunately, it is not possible to evaluate the risk of incorporating another pleiotropic gene into commercial crops because insufficient data are available on the frequency of pleiotropy.

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CHROMOSOMAL VARIATION AMONG PROGENY OF FACULTATIVE APOMICTIC GUAYULE

Dennis T. Ray* and Youngkoo Cho, Department of Plant Sciences, The University of Arizona, Tucson, AZ 85721

Progress toward the domestication of guayule (*Parthenium argentatum* Gray) as a domestic source of latex, has been slowed because of its complicated reproductive biology. This work was performed to help elucidate the facultative nature of apomictic reproduction in guayule. Ploidy level and six morphological characters were measured in one-hundred and eighty open-pollinated, half-sib progeny derived from twelve different apomictic tetraploid ($4n=4x=72$) female parents. The number of chromosomes observed among the half-sib progeny varied from 36 to 81, with the majority (77.3%) of the progeny with 72 chromosomes. All of the observed chromosome numbers could be explained either by meiotic reduction in the megaspore mother cells or fertilization of egg cells or both. The frequencies of meiotic reduction and fertilization resulting in these progeny were estimated to be 27.2 and 22.7%, respectively. Among the six measured morphological characters, significant correlations were found only between chromosome numbers and plant height ($r=0.37$) and leaf area ($r=0.31$).

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FIELD PERFORMANCE OF DRYLAND GUAYULE GENOTYPES IN SOUTH TEXAS

G.V. Latigo*, J.R. Smart and J.O. Kuti¹, USDA, ARS, Conservation and Production System Unit, Weslaco, TX 78596 and ¹Dept. Agronomy and Resource Sciences, Texas A&M University-Kingsville, TX 78363.

Guayule (*Parthenium argentatum* Gray) is a promising alternative to rubber tree (*Hevea brasiliensis* Muell. Arg.) for production of natural rubber in semiarid regions. For guayule to be commercially viable, substantial improvement in rubber yield is needed. Field studies were conducted on a dryland site in south Texas to evaluate productivity of selected guayule genotypes from Arizona and California. After 34 months of growth, no significant differences ($p=0.05$) were found among the genotypes for rubber yield. However, rubber yields for most of the genotypes increased more than 3-fold from that of last year (1992) yields. Genotype 'N9-5' from Arizona had the highest yield ($1,239 \text{ kg ha}^{-1}$). Survivability of the genotypes has progressively decreased over the years and survival rates for this year (1993) ranged from 48-25%.

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PB 244

CULTURE OF ISOLATED EMBRYOS OF DETERIORATED MAIZE SEED: A STRATEGY FOR RESCUING GERMLASM

Sheila A. Blackman and Eric E. Roos*, USDA-ARS, National Seed Storage Laboratory, 1111 S. Mason St., Ft. Collins, CO 80521

The low quality of some seed lots received by germplasm repositories such as the National Seed Storage Laboratory can thwart efforts to regenerate seed for storage. This germplasm is in danger of irretrievable loss. The aim of this work is to promote the germination, and hence regeneration, of such low quality seeds through sterile culture of the isolated embryos. Hybrid (B73xLH51) maize seeds were aged 5 y at 32°C and $0.037 \text{ g H}_2\text{O g}^{-1}$ dry wt. Vigor - but not viability - declined under these conditions. The effects of four factors on growth and germination were systematically examined. These were: seed pretreatments; antibiotics and fungicides; nutrients; and growth substances. Amongst the pretreatments, none surpassed partial hydration of seeds for 24 hr to $0.55 \text{ g H}_2\text{O g}^{-1}$ dry wt at 25°C prior to embryo dissection. Thiram (2.4 mg mL^{-1}) and kanamycin (50 ug mL^{-1}) effectively controlled bacterial and fungal growth with no deleterious effects on growth during culture of the isolated embryos. Exogenous sucrose (optimum 5 % wt/vol) significantly stimulated radicle growth in both deteriorated and non-deteriorated embryos. No other organic or inorganic nutrient stimulated growth. Naphthalene acetic acid did not affect growth while kinetin reduced radicle growth and stimulated coleoptile growth. Gibberellic acid (GA^3 at 10^{-5} M) significantly stimulated radicle growth in deteriorated embryos, whereas it promoted coleoptile growth in both deteriorated and non-deteriorated embryos. These data suggest GA or a GA-stimulated process may limit the growth of aged embryos.

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PB 247

BIOCHEMICAL CHARACTERIZATION OF CULTIVATED *OPUNTIA* SPECIES

J.O.Kuti* and C.M. Galloway¹, Dept. Agronomy & Resource Sciences, Hort. Research Lab., and ¹Dept. Biology, Texas A&M University-Kingsville, Texas 78363.

The use of protein profiles and isozyme banding patterns as genetic markers in cultivated *Opuntia* species was investigated using SDS-PAGE and spectrophotometric analysis of seeds and stem (cladode) tissues. Twenty morphologically different entries belonging to six *Opuntia* species were analyzed for total protein profile and three enzyme systems (superoxide dismutase [SOD], phosphoglucosmutase [PGM] and UDPG ppase). Seed proteins, mostly low molecular weights, were 3-fold that of cladode proteins. Marked differences in protein molecular weight were found among the entries. PGM activity, found only in the cladode tissues, differed among the entries. No UDPG ppase activity was found in either seeds or cladode tissues. Within the entries surveyed, identical SOD banding patterns were observed indicating some degree of similarity among the species. The preliminary results suggest that isozyme and protein profiles can be used as markers in genetic studies of cultivated *Opuntia* species.

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PB 250

PUNGENCY EVALUATION OF FIFTEEN SHORDDAY ONION CULTIVARS

J. Alcalá-Sáinz*, K.S. Yoo, L.M. Pike, Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133. R.W. Jones Jr., Texas A&M University Park, College Station, TX 77843-2119.

Fifteen shordday onion cultivars grown at two production locations (GB and ST) in the Lower Rio Grande Valley, Texas were evaluated for pungency levels using gas chromatography (GC) and pyruvic acid tests.

Significant differences ($P=0.05$) were observed between cultivars in the pyruvic acid and GC tests within each location. Pyruvic acid content ranged from 3.0 to $5.1 \text{ } \mu\text{mol} \cdot \text{g}^{-1}$ fresh wt. The amount of total sulfur volatiles measured by the GC method ranged from 28×10^3 to $58 \times 10^3 \text{ EU}$. The correlation coefficients between GC and pyruvic acid were 0.10^{***} and 0.18^{***} at the GB and ST location, respectively.

When the two locations were combined, no significant differences ($P=0.05$) were observed between cultivars or locations using the GC test. However, the pyruvic acid test showed significant differences between locations. This result indicated that each cultivar had a different response in pungency as influenced by production location or environment.

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PB 253

DISTRIBUTION OF QUERCETIN AND QUERCETIN GLYCOSIDES IN DIFFERENT-COLORED VARIETIES AND GENOTYPES OF ONION (*Allium cepa* L.) TISSUE

Bhimanagouda S. Patil* and Leonard M. Pike Department of Horticultural Sciences, Texas A&M University, College Station TX 77843-2133 USA

Representative varieties and genotypes of different colored onions were compared to determine the extent of differences in the distribution of quercetin and quercetin glycosides. The dry skins, outer rings, and inner rings were separated and extracted with ethanol to obtain quercetin glycosides that were then hydrolyzed to free quercetin, or aglycone. Free quercetin was used as the standard for quantification by reverse phase high

performance liquid chromatography (HPLC).

Significant difference ($P=0.05$) in total quercetin content was observed between dry skin and inner rings (edible parts). A decrease in total quercetin content was observed from the dry skin to inner rings. The highest total quercetin content was observed in the dry skins of Red bone variety (30.74 g/kg dry weight) while Contessa variety contain the least amount (0.082 g/kg dry weight). Total quercetin content in outer scales (1-2 scales) in Kadavan variety is the highest (481 mg/kg fresh weight); however, trace amounts are observed in Contessa. Inner rings (5-6 and 7-10 scales) contain less amount of total quercetin in all the varieties.

Outer scales of all the varieties except 1015Y and Contessa contain moderate amount (2.5-16 mg/kg fresh weight) of free quercetin. Kadavan contain the highest amount of free quercetin (20.64 g/kg dry weight).

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QUERCETIN AND QUERCETIN GLYCOSIDE CONTENT VARIATION IN DIFFERENT ONION (*Allium cepa* L.) VARIETIES AND GENOTYPES

Bhimanagouda S. Patil* and Leonard M. Pike, Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133, USA

The anti carcinogenic flavonol, aglycone, or free quercetin and quercetin glycoside content of seventeen onion varieties and 22 genotypes (Asgrow seed co.) and also 37 breeding lines (Texas A&M University) were analyzed by high performance liquid chromatography (HPLC). Quercetin glycosides were hydrolyzed into aglycones.

Total quercetin content in yellow and red onions varied from 80.34 to 286.4 mg/kg fresh weight in different varieties. Marked variation in total quercetin content between Texas A&M breeding lines (56-202 mg/kg fresh weight) and Asgrow breeding lines (54-287 mg/kg fresh weight) was observed. White onions contain trace amount of total quercetin. Free quercetin in Texas A&M breeding line 20272-G was 12.4 mg/kg fresh weight; however, other varieties and breeding lines contain negligible amount of free quercetin. It was concluded that the 'designer' onion varieties with high quercetin content for health consciousness can be produced.

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PB 259

GAIN FROM RECURRENT SELECTION IN FOUR FRESH-MARKET CUCUMBER POPULATIONS

Todd C. Wehner*, Department of Horticultural Science, Box 7609, North Carolina State University, Raleigh, NC 27695-7609

Several major traits (yield, earliness, quality) of interest to cucumber (*Cucumis sativus* L.) breeders are quantitatively inherited. The objective of this study was to determine the progress made on such traits using recurrent selection in 4 fresh-market cucumber populations (NCWBS, NCMB, NCES1, NCBA1). During population improvement, 1 to 2 replications of 200 to 335 half-sib families were evaluated for 5 traits: total, early and marketable fruits per plot, a quality rating, and a simple weighted index ($=2\text{Total}/2 + .3\text{Early} + .2\text{Marketable}/10 + .3\text{Quality}$). Families from each population were intercrossed in an isolation block during each summer using remnant seeds of the best 10% selected using the index. Progress was evaluated using a split-plot treatment arrangement in a randomized complete block design with 32 replications in each of 2 seasons (spring and summer). Whole plots were the 4 populations, and subplots were the 11 cycles (cycles 0-9 plus checks). Greatest gains were made for the NCBA1 population, with an average of 45% gain from cycle 0 to 9 over the 5 traits, and for early yield, with an average of 58% gain from cycle 0 to 9 over the 4 populations. Populations were improved for performance in a selected (spring season) as well as a non-selected environment (summer season).

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PB 282

INHERITANCE OF FRUIT FIRMNESS IN GENETICALLY PARTHENO-CARPIC PICKLING CUCUMBERS.

Kevin L. Cook*, August C. Gabert, and James R. Baggett, Department of Horticulture, Agriculture & Life Sciences 4017, Oregon State University, Corvallis, OR 97331.

The firmness of parthenocarpic (P) pickling cucumber cultivars is generally considered unacceptable for processing by the US pickling cucumber industry. Genetic improvement in firmness of P pickling cucumbers may increase their acceptability. Inheritance of fruit firmness (FF) in nonparthenocarpic (NP) cucumbers has been reported as quantitative but highly heritable with additive gene effects accounting for most of the genetic variation and no maternal effects. Genetic investigations were conducted at Brooks, Oregon, in

1992 and 1993 to determine the inheritance of FF in P cucumbers.

High heritability for FF was found with most genetic variance attributed to additive gene effects when F_2 's from four P gynocercious inbreds as females and five NP monocercious inbreds as males were used in 1992. Experiments in 1993, with inbred derived populations, revealed that dominant variance and maternal effects for FF may be substantial in certain populations with parthenocarpic germplasm.

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NEW EGGPLANT AND PEPPER CULTIVARS FOR HAWAII AND THE PACIFIC BASIN

K.Y. Takeda, University of Hawaii, Department of Horticulture, 3190 Maile Way, Room 102, Honolulu, HI 96822

Two long eggplant (*Solanum melongena* L.) hybrids, Nitta/Molokai F and Nitta/Waimanalo F, were released to growers. The hybrids represent an improvement over presently grown cultivars by producing higher yields of quality fruit. Quality factors such as dark maroon color, uniformity of fruit shape and long shelf life are important considerations for growers and consumers.

Two pepper varieties (*Capsicum annuum* L.), 'Kaala' and 'Waialua' were developed for those areas in Hawaii and the subtropics which have limited pepper production because of bacterial wilt (*Pseudomonas solanacearum*). The varieties were the result of a cross between 'Chabai Merah' and keystone Resistant Giant. 'Chabai Merah', a Malaysian pepper variety is highly resistant to bacterial wilt and rootknot nematode. 'Kaala' is a sweet pepper and is highly tolerant to bacterial wilt if grown at temperature below 27%. Waialua is a pungent type pepper and is highly resistant to bacterial wilt.

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EVALUATION OF SWEETPOTATO GERMPLASM FOR RESISTANCE TO THE SWEETPOTATO WEEVIL

Paul G. Thompson, John C. Schneider, and Boyett Graves, Mississippi State University, Box 9555, Mississippi State, MS 39762.

One hundred one accessions from the U.S. germplasm collection were evaluated in field trials for sweetpotato weevil resistance. Weevils were collected from 4 separate Mississippi locations during the winter of 1992-93. They were increased in culture and 6 adult females and 6 males were applied to the crown of each plant. percentage of uninjured storage roots ranged from 53 to 99. The most highly resistant control, Regal, had 79% and the most susceptible, Centennial, 60% uninjured roots. Uninjured root numbers ranged from 0.03 to 3.82 per plant. Regal had 2.1 and Centennial 1.88 uninjured roots per plant. Seventy-five accessions produced higher percentages of uninjured roots than Regal. However, 48 of those accessions produced less than one root per plant and previous results indicated that estimates with low storage root numbers lack precision. Fourteen accessions produced as many or more roots than Regal and also higher percentages and numbers of uninjured roots.

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CAROLINA BUNCH, A SWEETPOTATO FOR HOME GARDENS

J.R. Bohac*, P.D. Dukes, A. Jones, J.M. Schalk, H.F. Harrison, Jr., US Vegetable Laboratory, Charleston, S.C. and M.G. Hamilton, Clemson University, Edisto Research and Education Center, Blackville, S.C.

Carolina Bunch is a sweetpotato cultivar that combines high yield, excellent flavor and appearance with multiple pathogen and pest resistances. It is ideal for home or market gardens, because of its short vine and bunch habit that allow for production of high yields in a limited space. The roots are fusiform with uniform shape and a smooth, bright, light copper skin and dark orange flesh. When baked, the roots have a smooth texture and are sweet, moist and have excellent flavor and appearance. This sweetpotato can be grown virtually without pesticides. It has very high levels of resistances to southern root knot and other species of nematodes, *Fusarium* wilt, feathery mottle virus, sclerotial blight in plant beds, and *Streptomyces* soil rot. It has good resistance to many soil insects including several species of wireworm, *Diabrotica*, *Systema*, and flea beetles. In the southern US, it yields better than 'Jewel' in a growing season of 110-120 days. Foundation roots are available in limited quantities from South Carolina Foundation Seed Association, Inc, 1162 Cherry Hill Rd, Clemson SC 29634-0393.

BREEDING SAVORY PEPPER" FOR ADAPTATION IN NORTHEAST U.S.

Paul Grun* and M.D. Orzolek, Dept. of Horticulture, The Pennsylvania State University, 102 Tyson Bldg., University Park, PA 16802-4200

Savory Peppers™ (Sp™) is the low heat form of *Capsicum chinense* from northern South America where it is widely used as a condiment. We are adapting it to northeastern conditions through introgression of genes from adapted *C. annuum*, selection within SP™, and use of improved culture methods. Introgression is progressing in spite of species isolation barriers expressed as failure of F₁ seeds to germinate, and F₁ and later generation male sterilities. Selection has been carried out on plants of two landraces, producing ten improved strains which were tested at three stations last summer: 1) west PA on sandy soil with long growing season; 2) central PA on clay loam with short growing season, and 3) eastern PA on clay loam with long growing season. Strains of both landraces yielded well in region 1), and poorly in region 2), and one landrace yielded well in region 3), while those of the other yielded poorly as a result of early wilt. Roles of soil and temperatures in producing these results will be discussed.

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COTYLEDON POSITION AS A SPECIES CHARACTER IN *PHASEOLUS*

Rebecca Nelson Brown* and Peter D. Ascher, Department of Horticultural Science, University of Minnesota, 1970 Folwell Ave., St. Paul, MN 55108

The methods of Wall and York (1957) were used to measure cotyledon position in two populations of three species interspecific *Phaseolus* hybrids and in the single species cultivars and accessions of *P. coccineus*, *P. acutifolius*, and *P. vulgaris* used as parents. Cotyledon position was represented by the length of the epicotyl as a percentage of the total length of the seedling's stem from the first root initial to the base of the primary node. Progeny of interspecific crosses between *P. coccineus* and *P. vulgaris* have been shown to inherit the cotyledon position of the cytoplasmic parent. The objectives of this study were to determine if three species hybrids also inherited the cotyledon position of the cytoplasmic parent, and to determine if *P. acutifolius* could be distinguished from *P. vulgaris* by its cotyledon position. Results indicated that the cotyledon positions of the three species hybrids did not differ significantly from the cotyledon positions of cultivars of the species used as the cytoplasmic parent for both *P. vulgaris* cytoplasm and *P. coccineus* cytoplasm. Further, the cotyledon position of the *P. acutifolius* accessions did differ significantly from the cotyledon positions of both the *P. vulgaris* cultivars and the three species hybrid with *P. vulgaris* cytoplasm. These results suggest that cotyledon position may indeed be a species-specific trait for *Phaseolus* in Lamprecht's sense of the term.

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RUST REACTION TYPES AND LEAF PUBESCENCE IN DRY BEAN LINES FROM MALAWI

J. M. Bokosi*, D. P. Coyne¹, J. R. Steadman² and D. O'Keefe², University of Nebraska, Lincoln, NE 68583

Twenty-four diverse bean (*Phaseolus vulgaris* L.) lines (Malawi) derived from single plant selections from landraces were evaluated for bean rust (*Uromyces appendiculatus*) resistance and leaf pubescence in the greenhouse (NE). A randomized complete block design was used. Each line was inoculated on the primary leaf (35-60% leaf expansion) 7 days after planting and on the 4th trifoliate leaf (10-20% leaf expansion) with two rust strains, D82VC74fh (Dominican Republic) and A88TI-20a (Tanzania). Rust uredinia size was recorded on the 14th day after inoculation. Three lines, 'Nasaka', 16-6, and 'Kamtsilo' had specific resistance (SR) to one or the other of the strains but none to both strains. Many lines were susceptible on the primary leaves but had moderate to highly resistant reactions on the 4th trifoliate leaves indicating adult plant resistance (APR). APR was the main type of rust resistance for most of these 24 lines. Many of these APR lines were glabrous. No association was observed between APR and pubescence.

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PB 323

SELECTION FOR ASTER YELLOWS RESISTANCE IN CARROT

W.H. Gabelman, I.L. Goldman*, and D.N. Breitbach, University of Wisconsin-Madison, Department of Horticulture, 1575 Linden Drive, Madison, WI 53706

Aster yellows, an insect-vectored disease caused by a mycoplasma-like organism, limits vegetable crop production in the Midwestern U.S. A breeding effort was initiated in 1982 to develop aster yellows resistance in carrot. A synthetic population (AYSYN) composed of 5 open-pollinated varieties and 4 inbreds was assembled in 1982. Inbred lines and hybrids were extracted from AYSYN using a variety of methods. Selection in artificially-infected field sites was carried out from 1982 until 1989. Twenty-three inbreds and 3 hybrids were developed from AYSYN during the selection process. Replicated field experiments were conducted in 1990, 1991, and 1993 to determine the relative aster yellows resistance of these lines and hybrids

in comparison with 6 check cultivars. Averaged over years, significant differences were detected for percent aster yellows infection among genotypes. Lines selected for resistance had a mean of 12% infected plant per plot as compared to 24% infection for standard cultivars. Results demonstrate the effectiveness of inbreeding and field selection for aster yellows resistance. This breeding effort represents the first report of aster yellows-resistant carrot germplasm.

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PB 326

PISTIL INFLUENCE ON GROWTH OF POLLEN TUBES OF *P. X DOMESTICUM*

Mary Stuart* and Pablo Jourdan, The Ohio State University, 2001 Fyffe Court, Columbus, OH 43210

The regal pelargonium (*P. x domesticum*) is generally characterized by low fertility and poor seed set. In studies designed to assess factors that contribute to low fecundity in this crop we have examined genotype interactions among various cultivars and have identified lines that differ in degree of male and female fertility.

The objective of this study was to examine genotypic variation, other than self-incompatibility, of *P. x domesticum* pistils in supporting the development of the male gametophyte. Variation in pollen germination and growth was assessed after crossing either a male of high fertility or a male of poor fertility to nine different selections of varying female fertility. Styles were harvested 2 hours after pollination and examined using fluorescence microscopy to determine the number of germinated pollen grains on the stigma and the number of pollen tubes growing down the style.

Female selections displayed large differences in their ability to support pollen tubes. Styles from different females pollinated with the same male varied in average number of pollen tubes from 30 to 2.

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REPRODUCTIVE BIOLOGY OF *VIGNA CARACALLA* (= *PHASEOLUS CARACALLA*)

Neil O. Anderson* and Peter D. Ascher, Department of Horticultural Science, University of Minnesota, St. Paul, MN 55108

The snail flower, *V. caracalla*, was a popular ornamental flowering plant in conservatories at the turn of the century. It's popularity was due, in part, to its showy, orchid-like flowers whose fragrance rivals *Stephanotis*. The indeterminate, vining growth habit can produce plants > 20 feet in height. *V. caracalla* is of interest for genetic and evolution studies since it is an ancestral species and possesses diagnostic traits of both *Phaseolus* (coiled style, leaf length/width ratios) and *Vigna* (> 10 seeds/ovary, long seed pods). However, its reproductive biology and use as an intergeneric hybrid bridge is unknown. Plants were examined for male and female fertility, self compatibility, and cross compatibility. Genotypes were self-incompatible; with one exception, self seed set did not occur following artificial manipulation. Selfed flowers abscised within 1-2 days post-pollination. Accessions were cross-compatible and highly fertile. To date, intergeneric hybridizations performed with *P. coccineus* --the ancestral *Phaseolus* --have aborted following fertilization.

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PB 335

HERITABILITY ESTIMATES OF POWDERY MILDEW RESISTANCE IN A TWO-YEAR-OLD LILAC POPULATION.

Randy Johnson, USDA, ARS, U.S. National Arboretum, 3501 New York Ave. NE, Washington DC 20002-1958

Twenty-one control-pollinated families of lilac (*Syringa*) were evaluated for the presence of powdery mildew (*Microspheara syringae*). Because disease developed first in the lower portions of the plant and moved up, infection was scored from the lowest (1 = only on the lower quarter of the plant) to the highest quarter of the plant (4 = present on all quarters of the plant). Family means for mildew score ranged from 2.3 to 3.8 and averaged 3.1, and for height ranged from 59 to 107 cm and averaged 82 cm. Narrow sense and broad sense heritabilities were estimated to be 0.08 and 0.27 respectively. Since any selections will be clonal, this relatively large proportion of non-additive variance can be fully utilized. There was a significant positive correlation between family means of height and mildew score (0.58); however, the phenotypic correlation between height and mildew score was -0.11. For this population the genetic correlation between mildew infection and height was positive (the taller families on average had mildew farther up the plant), but the environmental correlation was negative.

SELF INCOMPATIBILITY (SI) IN DISTYLOUS *LYTHRUM ALATUM*, WINGED LOOSESTRIFE

Neil O. Anderson* and Peter D. Ascher, Department of Horticultural Science, University of Minnesota, St. Paul, MN 55108

Lythrum species (Lythraceae), found both in the Old and New Worlds, possess heterostyly (macroscopic differences in anther and style lengths). SI is linked with heterostyly in tristylous *L. salicaria*, allowing for visual identification of compatibility relationships. Five Minnesota populations of distylous *L. alatum* (short & long styles/anthers) were examined for fertility and linkage between distyly and SI. Pollen was not inhibited from germination, stigmatic penetration, or stylar growth in compatible crosses. Average cross-compatible seed set for each population was 7-33 seeds/capsule for short- and 27-69 for long-styled plants. With the exception of the Iron Horse Prairie population, there were no significant differences in mean seed set/capsule between genotypes, style morphs, or their interaction for compatible crosses. Zero self seed set predominated, although 0.8 ± 1.8 seeds/capsule were produced by short styles and 1.2 ± 2.3 by long styles from Iron Horse Prairie. In those individuals that were SI, pollen tube growth was inhibited following self pollinations.

30 POSTER SESSION 4 (Abstr. 460-484) Breeding/Genetics/Molecular Markers

GROWTH OF BIOLUMINESCENT *XANTHOMONAS CAMPESTRIS* PV. *CAMPESTRIS* IN THE FIELD ENVIRONMENT AFTER INOCULATIONS WITH A COMPATIBLE NONVIRULENT OR INCOMPATIBLE PATHOVAR. Fenny Dane and Joe Shaw, Department of Horticulture and Department of Botany and Microbiology, Auburn University, AL 36849.

Growth of genetically engineered, bioluminescent, *Xanthomonas campestris* pv. *campestris* (Xcc), causal agent of black rot of crucifera, was followed in cabbage plants after the plants were prior inoculated with *Xanthomonas campestris* pv. *vesicatoria* (Xcv) or a nonvirulent strain of Xcc. Wound inoculation with Xcv induced a hypersensitive response and restricted the bioluminescent bacteria-host interaction if prior inoculation was carried out one day before challenge inoculation. Mist inoculation with Xcv was effective in restricting Xcc when the time period between inoculation and challenge was 6 days. In field studies, however, mist inoculation with Xcv or a nonvirulent strain of Xcc, one week before challenge inoculation with bioluminescent Xcc, did not significantly effect the growth and persistence of bioluminescent Xcc. The bioluminescent strain overwintered endophytically in cabbage and could be detected for many months throughout the vegetative period of the host.

MAPPING RAPD MARKER DIVERSITY IN *PHASEOLUS VULGARIS*

Paul Skroth* and Jim Nienhuis, University of Wisconsin, Department of Horticulture, 1575 Linden Drive, Madison, WI 53706, and Geunhwa Jung and Dermot Coyne Department of Horticulture, University of Nebraska, Lincoln, Nebraska 68583.

Knowledge of genetic relationships and genetic diversity among accessions is essential for the efficient construction, maintenance and utilization of large ex-situ germplasm collections. Furthermore, streamlining of large collections into core collections necessitates validation of germplasm sampling techniques. DNA molecular markers provide potentially unbiased estimators of genome diversity and may facilitate organization, maintenance, and sampling of plant genetic resources. Our data suggests that RAPD markers will be a good tool for testing core collection concepts and organizing genetic diversity in common bean. However, the genomic distribution of markers is unknown. Currently we are using recombinant inbred (RI) populations to place RAPD markers in the context of the bean genetic map. We have evaluated the distribution of RAPD markers in three RI populations: Bat93 x Jalo EEP558, PC50 x Xan159, and BAC6 x HT7719. Cultivated *P. vulgaris* has two primary centers of diversity Mesoamerican and Andean, the RI populations used for mapping RAPD markers are Meso x Andean, Andean x Andean, and Meso x Meso crosses respectively. In the Bat93 x Jalo EEP558 population 383 markers have been mapped for a map length of 735 cM. However, approximately 150 of these markers are members of 9 clusters which span only 90 cM. This inter gone pool map is being integrated with linkage maps constructed in the other two populations to compare within and between gene pool marker distributions and to evaluate clustering of markers on the different maps. Implications for the application of RAPD markers will be discussed.

RAPD MAPPING OF THE ASPARAGUS (*ASPARAGUS OFFICINALIS* L.) GENOME

Chunxiao Jiang*, Kenneth C. Sink, Michigan State University, East Lansing, MI 48824

RAPD (Random Amplified Polymorphic DNA) is being utilized to construct a molecular genetic linkage map. The mapping population used is comprised of 65 individuals. Of the 240 decamer primers (Operon) tested to date, 50 polymorphic bands have been resolved. The 50 markers are divided into two groups according to the genotypes of the two parents. The first group is where the female parent is heterozygous and male parent is homozygous and it has 17 markers, while the second group, in which male parent is heterozygous and female parent is homozygous, has 33 markers. Analysis of the two groups by MAPMAKER indicated that two linkage groups are formed in the first group, and five linkage groups are formed in the second group. Sex type is controlled by the M locus. Genetic experiments have demonstrated that females are homogametic (mm) while male plants are heterogametic (Mm) for the sex locus. Two bulks of genomic DNA created by using 10 male and 10 female individuals in the population were screened to identify RAPD markers associated with the sex locus. RAPD marker OCP15-984 is closely linked with the M locus (7.6 cM).

IDENTIFICATION OF RAPD MARKERS ASSOCIATED WITH CANNING QUALITY IN NAVY BEANS.

Kimberly J Walters*, George L. Hosfield, James D. Kelly, Michigan State University, Crop and Soil Sciences Dept., East Lansing, MI 48824.

Ninety-eight percent of the navy beans (*Phaseolus vulgaris*) grown in the US are processed. Thus, new cultivars considered for release must meet industry standards. Canning quality behaves as a classical QTL which precludes its selection and evaluation in early generations. Such delays add a measure of inefficiency to a breeding program. Indirect selection for canning quality using molecular markers could increase efficiency. RAPD markers are more useful than RFLP's, in *Phaseolus*, due to a simpler protocol and a higher level of polymorphism within genetically related cultivars. Three populations of RIL's, derived from crosses between cultivars with standard and sub-standard canning quality, were screened to identify markers associated with canning quality. Material for evaluation was grown at two locations, in three replications and processed, in the Food Science Processing Lab, following industry standards. Quality traits measured were: processed texture, color and appearance. Associations of putative markers with canning quality were identified using ANOVA and Mapmaker programs

IDENTIFICATION OF RAPD MARKERS ASSOCIATED WITH QTLs CONTROLLING DROUGHT TOLERANCE IN PINTO BEANS.

Kristin Schneider*, James D. Kelly, Jorge Acosta G. Michigan State University, Crop and Soil Sciences Dept., East Lansing, MI 48824.

Common beans, considered sensitive to moisture stress, are an important commodity in developing countries such as the Mexican Highlands where intermittent drought conditions are prevalent during the growing season. The selection and development of high performing cultivars under drought stress is confounded by the quantitative nature of drought tolerance. To employ indirect selection in earlier generations, RAPD markers were identified that associated with QTLs controlling performance under drought stress. RAPD markers are preferred for use in *Phaseolus vulgaris*, over RFLPs, because they generate polymorphisms between genetically related germplasm. 48% of 620 arbitrary primers screened against three parents of two F6 derived recombinant inbred pinto populations were polymorphic for one or more bands. These polymorphisms were screened against RILs in each population and associations were determined using one-way ANOVAs and Mapmaker. Yield data used for determination of associations was collected over five years in MI and Mexico where both stress and non stress treatments were applied.

QTL MAPPING AND MARKER-ASSISTED SELECTION USING INDEPENDENTLY GENERATED INBRED BACKCROSS TOMATO POPULATIONS

Steven R. Triano* and Dina A. St. Clair, Department of Vegetable Crops, University of California, Davis, CA 95616-8746

The inbred backcross (IBC) breeding method is being used to introgress genes controlling high fruit soluble solids from a wild tomato species (*Lycopersicon cheesmanii* f. *minor*) into a California processing tomato cultivar (*Lycopersicon esculentum* cv. UC204B). One IBC tomato population (i.e. P1: 106 lines) is being used to map

quantitative trait loci (QTL) for soluble solids and other traits. A genetically related but independently generated IBC population (i.e. P2: 96 lines) is being used to test the efficiency of QTL-linked RFLPs for indirect marker-assisted selection (MAS) to improve soluble solids. P1 was analyzed for fruit quality traits in a replicated field design over 2 years. Twelve P1 lines were significantly greater than UC204B for soluble solids, and also had acceptable fruit weights and horticultural traits. All twelve lines have been publicly released for further breeding efforts. In P1, we have identified RFLP markers that have significant correlations to QTL. Some of these markers map to regions previously reported by other researchers to contain QTL for the same traits. We will use 70-80 markers spaced approximately 10-20 cM apart across the genome to screen P1 and map QTL. The RFLP analyses are currently in progress. P2 was replicated for one year using the same field design as P1, and analyzed for the same traits. P2 will be screened with QTL-linked RFLPs identified in P1 to test the consistency of QTL locations between independently derived populations. P2 lines selected using RFLP data will be compared to P2 lines identified by classical selection indices. This will indicate if MAS for QTL is effective in a population (P2) genetically independent from the mapping population (P1).

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IDENTIFICATION OF MOLECULAR MARKERS LINKED TO LOW TEMPERATURE RESPONSES

R.A. Teutonico*, J.P. Palta², T.C. Osborn¹

¹Dept of Agronomy, ²Dept of Horticulture University of Wisconsin, 1575 Linden Drive, Madison, WI 53706, USA

Identification of the genes involved in low temperature responses in oilseed *Brassica* could lead to genetic improvement of this crop and other species. We developed a genetic linkage map for *B. rapa* using restriction fragment length polymorphisms (RFLPs) and identified molecular markers which are linked to genes controlling vernalization requirement and freezing tolerance. We mapped the location of a group of cold-regulated ('cor') genes from *Arabidopsis thaliana* in this population and determined their association with these cold responses. We developed genetically fixed, recombinant inbred lines of *B. rapa* to assay the physiological processes involved in these cold responses. Specifically, we measured the differences in lipid composition of the plasma membranes of acclimated and nonacclimated plants of a subset of this population. We will determine if the genes involved in the physiological responses to low temperature are also associated with the acquisition of freezing tolerance.

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RAPD ASSAY TO IMPROVE BRASSICA GENETIC RESOURCES COLLECTION MANAGEMENT

Winthrop B. Phippen¹, Stephen Kresovich², and James R.

McFerson^{1*}, ¹USDA-ARS Plant Genetic Resources Unit, Geneva, NY 14456-0462 and ²USDA-ARS Plant Genetic Resources Conservation Unit, Griffin, GA 30223-1797.

Genetic variation and relationships in genetic resources collections can be assessed using molecular genetic markers. We examined the applicability of the RAPD assay for quick, cost-effective, and reliable use in improving collection management. Fourteen accessions of *Brassica oleracea* spp. *capitata* 'Golden Acre' (cabbage) were screened using nine decamer oligonucleotide primers. We obtained 110 reproducible fragments, of which 80 were polymorphic, ranging in size from 370-1730 bp. Individual accessions were readily distinguished. A cluster analysis of genetic distances generated by bootstrapping reflected all known genetic relationships, except one. Bulking strategies were also investigated. RAPD markers can be applied to gene bank management to measure variation, identify accessions, and establish genetic similarity at the intra-specific level addressing the needs of both curators and users.

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RAPDS ANALYSIS OF GENETIC DISTANCE BETWEEN WILD AND CULTIVATED TEPARY BEAN LINES

Jan E. Paul Debaene* and Laren Robison, Department of Agronomy and Horticulture, 275 WIDB, Brigham Young University, Provo, UT 84602.

Tepary beans (*Phaseolus acutifolius* A. Gray) are considered drought and heat tolerant, desirable characteristics for arid regions. Knowing the genetic distances among tepary lines can indicate both compatibility for intraspecific crosses and potential for Interspecific *P. acutifolius* x *P. vulgaris* hybrids. Fifteen tepary lines, including cultivars and landraces, were compared to two pinto bean varieties using random amplified polymorphic DNA's (RAPDs). At the present time polymorphisms have been clearly identified between wild and cultivated teparies and the pinto bean. An amino acid profile is also being determined using HPLC. More work needs to be completed before relationships among cultivated teparies can be established.

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INTER- AND INTRA-LINE GENOTYPIC VARIATION OF U. S. COLLARD CULTIVARS AND LANDRACES DETERMINED BY RAPD ANALYSIS

Mark W. Farnham*, USDA-ARS, U. S. Vegetable Laboratory, 2875 Savannah Highway, Charleston, SC 29414

Collard (*Brassica oleracea* L. var. *acephala*) is an important vegetable the southeastern U. S. There are few (about 10) commercial cultivars, half being open-pollinating (OP) lines, the remainder more recent F₁ hybrids. There is a potential untapped *B. oleracea* germplasm pool in the form of collard landraces perpetuated by southeastern gardeners and farmers. To determine the amount of genetic variation among cultivars and also whether landraces represent unique genotypes, ten cultivars and eight lines or landraces were evaluated using RAPD analysis. Decamer primers were used to amplify total genomic DNA and to differentiate collard lines and other *B. oleracea* crop cultivars. Additionally, individuals of an OP collard cultivar and a land-race were analyzed to evaluate intra-line variation. Virtually all primers detected polymorphic bands among lines although some identified considerably more variants. Intra-line analysis indicated that OP lines are genetically broad-based populations. Many unique RAPD markers were identified in landraces indicating that the lines represent unique genotypes and that further line collection is warranted.

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DNA AMPLIFICATION USING *Taq* POLYMERASE AND STOFFEL FRAGMENT IN POLYPLOID SWEETPOTATO

Mario I. Buteler*, Don R. LaBonte¹ and James H. Oard², ¹Dept. of Horticulture and ²Dept. of Agronomy, LSU Agricultural Center, Baton Rouge, LA 70803

RAPD and the single dose polymorphic band (SDPB) are powerful tools for genome map construction of higher polyploids, such as hexaploid sweetpotato. Duplication in the genome of higher polyploids results in fewer polymorphisms per primer screened than one would expect in diploids. The *Stoffel* fragment (Sf) is suggested as an alternative to the most commonly used *Taq* DNA polymerase to maximize the number of polymorphisms. Genomic DNA from two sweetpotato varieties, 'Excel' and 'Beauregard', and F₁ progeny was isolated using a modified CTAB procedure. The DNA was assayed with twelve primers from Operon Technologies groups A and F. Each enzyme was tested with and without a ramp temperature treatment between the annealing and the extension temperatures. Results are based on three separate amplifications and electrophoretic runs. Band reproducibility was better using Sf than *Taq*; unfortunately, resolution was lower making bands difficult to score. 8.4% more scorable bands and 20.3% more storable polymorphisms were obtained with *Taq*. The ramp treatment did not alter results using Sf, but did improve the reproducibility of *Taq* and ease scoring. The number of bands and their location were the same.

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GENETIC ENGINEERING OF STARCH USING CLONED STARCH BRANCHING ENZYME GENES

Dane K. Fisher*, Charles D. Boyer, and Mark Guiltinan, The Pennsylvania State University, 102 Tyson Bldg., University Park, PA 16802 and Oregon State University (CDB)

During plant starch biosynthesis, starch branching enzymes (SBE) catalyze α-1,6 branch point formation in starch, and thus are responsible for many properties of the starch polymer. Recently we have cloned cDNAs encoding the two major branching enzymes in developing maize endosperm, SBEI and SBEII. These genes are being used to alter starch biosynthesis via genetic engineering strategies. Transgenic tobacco plants with sense and antisense constructs of SBEI and SBEII have been produced. No major difference in the phenotypes of control and transgenic plants have been observed. Initial experiments demonstrated the transcription of the introduced genes. Enzyme levels and the molecular properties of the starch in the transgenic plants will be determined. These experiments will provide us with information as to the role of starch branching enzymes in starch biosynthesis, the feasibility of creating novel starch, and the effect altered starch has on plastid development and photosynthesis.

AGROBACTERIUM- MEDIATED TRANSFORMATION OF CAULIFLOWER FOR CONTROL OF FLOWER SENESCENCE

Wendy Wagoner, J. Stamp, H. Matthews*, J. Kellogg and R. Bestwick
Agrirope Inc. 8505 SW Creekside Place, Beaverton, OR 97005

Ethylene is a known causal factor in the decay and senescence of fruits and vegetables. The aim of the present study was to incorporate a gene for control of ethylene biosynthesis in order to prevent or delay the senescence of the cauliflower curds. We first developed a reproducible transformation system using marker genes for beta glucuronidase (GUS) and antibiotic resistance. *Brassica oleracea* L. var. *botrytis* was transformed by inoculating hypocotyl explants with the *Agrobacterium tumefaciens* strains C58 or EHA101 containing plasmids pAG5110, pAG5420, or pAG5520. The plasmid pAG5110 contains the genes for neomycin phosphotransferase II (NPTII) and GUS. The plasmids pAG5420 and pAG5520 contain a functional gene for S-adenosylmethionine hydrolase (SAMase) under an ethylene or wound inducible promoter, respectively. Hypocotyl explants were screened on regeneration medium with kanamycin for selection of transformants. Shoot regeneration occurred within 4-6 weeks and morphologically normal plants developed within 3-4 months. The transgenic nature of the plants was confirmed by histochemical GUS assay, an ELISA based NPTII assay and Southern blot analysis. Transgenic plants outplanted in the greenhouse are being evaluated and selfed to study expression and inheritance pattern of the introduced trait.

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GENETIC TRANSFORMATION AND REGENERATION OF MUNG BEAN USING *AGROBACTERIUM RHIZOGENES*

Shuhua Zhan*, Zhongfang Lu and Y. Huang, Institute of Pomology, Hubei Academy of Agricultural Sciences, Wuchang, Hubei 430209, China and Wuhan Institute of Botany, Academia Sinica, Wuhan, Hubei 430074 China.

Mung bean (*Vigna radiata* L.) is one of the economically important crops in Southeastern Asia and also grows in USA. Genetic transformation of mung bean has been achieved using an *Agrobacterium*-mediated transformation system. Two transformation methods were used in this study. With the leaf-disk transformation method, freshly cut leaf strips from young seedlings of mungbean were co-cultivated for 72 hours with either a wild-type *A. rhizogenes* strain 11325 or the strain containing an additional binary vector carrying the *npt* gene. In another method, agrobacteria were applied to wounded hypocotyls of aseptically germinated seedlings. After infection, the explants were placed on shoot induction medium. Within 3-4 weeks, shoots developed from the edges of leaf disks as well as from the inoculated sites on hypocotyls. Putatively transformed shoots were selected *in vitro* based on their ability to root in the kanamycin-containing medium. The *npt* gene fragment and a few of T-DNA fragments from the wild-type Ri plasmid were detected in regenerated mungbean plants by Southern blot analysis. These results suggested that foreign DNAs from both the Ri plasmid and the binary vector had integrated into the genome of mung bean. These transformation systems for mung bean can now be used to introduce agronomically desirable traits into this crop for its genetic improvement.

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EFFECT OF PRIOR INOCULATION OF LEAVES OF DRY BEANS WITH THE COMMON BLIGHT PATHOGEN ON THE DISEASE REACTION OF SUBSEQUENTLY INOCULATED LEAVES AND PODS AND TEE REACTION OF DETACHED VERSUS ATTACHED PODS

Ariyaratne H. M.*, D. P. Coyne, Anne K. Vidaver, and K. M. Eskridge,
University of Nebraska, Lincoln, NE 68583-0724

Breeding for resistance is a major method to control the common bacterial blight disease caused by *Xanthomonas campestris* pv *phaseoli* (*Xcp*) in common bean (*Phaseolus vulgaris* L.). It is necessary to determine if prior inoculation of the first trifoliate leaf with *Xcp* will influence the subsequent reaction in other plant parts through induced resistance. It is difficult to get an accurate estimate of heritability (H) of disease reaction in pods since environment (E) greatly affects the H estimate if flowering occurs over extended time periods. Thus the disease reaction in attached pods vs detached pods was also observed. Four common bean lines were used in a split plot design with two replications. Two bacterial strains were used for inoculations. Two growth chambers were used as replicates. The first trifoliate leaves, later developed leaves and attached pods and detached pods were inoculated. No effect of prior inoculation on the disease reactions of subsequently inoculated leaves and pods were observed indicating that the different plant parts can be inoculated at different times. Detached and attached pods showed similar disease symptoms. The former may be used to reduce E variance and improve H estimates.

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INHERITANCE OF A TWISTED POD CONDITION IN PHASEOLUS VULGARIS L.

J. R. Baggett* and D. Kean, Department of Horticulture,
Oregon State University, ALS 4017, Corvallis, OR 97331-7304

An abnormal pod condition, in which bean pods are twisted, sometimes as much as 360°, was discovered in a selection of OSU 5256, a Bush Lake breeding line. The amount of twisting of affected pods and the number of affected pods/plant are both variable. F₂ progenies from crosses between twisted pod line 5256-1 and two normal bush Blue Lake cultivars segregate 3 normal:1 twisted, showing that the twisted mutant is controlled by a single recessive gene.

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THE EFFECT OF POD DETACHMENT CHARACTERISTICS ON POD DAMAGE, POD RECOVERY, AND AMOUNT OF TRASH IN PROCESSING GREEN BEANS.

Al Lien* and James R. Baggett, Horticulture Dept, AL-S Building
Room 4017, Oregon State University, Corvallis, OR 97331.

Pod detachment characteristics were studied in 'EZ Pick', an unusually easy-picking cultivar, and 'OREGON 91G', a normal cultivar. When 'EZ Pick' pods were harvested by hand or by machine, they tended to separate at the pedicel-stem juncture or at the pedicel-calyx juncture, while 'OREGON 91G' pods tended to break at the neck. When machine-harvested, 'EZ Pick' had fewer broken pods, a higher recovery rate, and more trash than did 'OREGON 91G'.

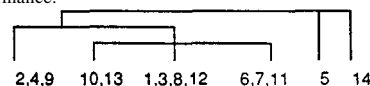
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GENETIC DIVERSITY AMONG BOTANICAL VARIETIES OF CUCUMBER (*Cucumis sativus* L.)

J. E. Staub*, USDA-ARS and University of Wisconsin, Horticulture department, 1575 Linden Dr. Madison, WI 53706; and Jinsheng Liu, Dept. Nanjing Agricultural University, Nanjing 210014, P.R.C.

The genetic diversity among *Cucumis sativus* var. *sativus* (commercial cucumber) (1), var. *anatolicus* (2), var. *cilicicus* (3), var. *europaeus* (4), var. *falcatus* (5), var. *indo-europaeus* (6), var. *iranoturanius* (7), var. *izmir* (8), var. *sikkimensis* (9), var. *squamosus* (10), var. *testudaceus* (11), var. *tuberculatus* (12), var. *vulgatus* (13), and var. *hardwickii* (14) were assessed using 7 morphological characteristics and 9 isozyme loci to determine their potential use for plant improvement. Results of morphological comparison below. Isozyme and morphological analysis did not result in similar dendrogram depictions. Varieties 13 and 3 might have potential in plant improvement based on yield performance.



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CORE COLLECTION OF *CAPSICUM* GERMPLASM

Pamela Cole Rodgers* and Paul W. Bosland, Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, NM 88003.

Preservation of genetic diversity is of paramount importance in germplasm. A method of collecting, storing, and organizing genetic material to include maximum variability and to minimize repetition within the collection is a "core collection." To assist the National Plant Germplasm System in developing a core collection, or core subset of *Capsicum* germplasm, field evaluations were conducted from 1989 to 1993 at New Mexico State University. In determining how best to organize the core subsets, we believe the objectives of a *Capsicum* core subset should be to increase the efficiency of evaluation and thus the utilization of existing collections and to provide for a manageable and representative selection of available *Capsicum* germplasm for use in research and plant breeding. We are using a modified IBPGR *Capsicum* descriptor list to evaluate the collection. With these objectives in mind, we are suggesting the following approach to *Capsicum* core subsets. At least one accession of each *Capsicum* species is contained in the core. The most economically important species, *C. annuum*, represents the majority of accessions. Within *C. annuum* the core subsets are grouped by pod-type (ancho, bell, jalapeno, etc.). The pod-type is analogous to races in maize (*Zea mays*).

THE *PISUM* P.I. AND MARX GENETIC STOCK COLLECTIONS

Charles J. Simon*, and Richard M. Hannan, USDA, ARS, Western Regional Plant Introduction Station, WSU, Pullman, WA. 99164-6402

The USDA *Pisum* collection, currently consisting of 2881 P.I. lines, is in its third year of maintenance and distribution from the Pullman WA location, after being transferred from the Geneva, NY P.I. Station. It is our policy to distribute only material that is free of the Pea Seedborne Mosaic Virus. To that end 2300 of the lines have undergone an extensive virus cleanup program to verify infection status and provide virus free seed. Virus-free seed has been undergoing multiplication under greenhouse and screenhouse conditions in Pullman, and under field conditions at research station at Central Ferry, WA. Seed is now available for approximately 1700 lines. A two-year program to update descriptor information for the 19 most important descriptors identified by the *Pisum* CAC was initiated this summer. A pea core collection has been developed and is being examined for representative diversity with molecular markers.

The G.A. Marx genetic stocks collection was transferred to Pullman in February, 1994. Over 400 of the 500+ lines designated for that collection have been increased in Geneva, NY under greenhouse conditions and are currently available for distribution. A computer database describing this collection is near completion, as is a bound catalog that will be made available. Lines of the collection are being given P.I. numbers, and the database will be uploaded into the new version of the USDA GRIN computer system that should be on-line sometime in 1994.

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HORTICULTURAL GERMPLASM MAINTAINED AT THE WESTERN REGIONAL PLANT INTRODUCTION STATION

Richard M. Hannan*, Charles J. Simon, and Raymond L. Clark, USDA, ARS, Western Regional Plant Introduction Station, WSU, Pullman, WA 99164-6402

The Horticulture Program at the Western Regional Plant Introduction Station is responsible for the maintenance and distribution of germplasm collections of ten crop genera. These ten genera include over 28,000 accessions of 267 species of germplasm with either food or ornamental potential. The largest collection is beans (*Phaseolus*, > 11,500 accessions) which includes 32 species. Large collections of the cool season food legumes include *Cicer*, *Pisum* and *Lens*. Smaller legume collections include *Lupinus*, *Lathyrus*, *Trigonella* and *Vicia*. Although there are fewer than 3300 accessions within these four genera, there are 134 species represented. Although smaller in number of accessions, the *Allium* and *Lactuca* collections are extensively utilized for food and ornamental development programs. Associated with the curation and seed maintenance of these crops is a seed-borne virus eradication program, the development of core collections, and expansion of the evaluation data and other documentation into the Germplasm Resources Information Network.

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GENETIC DIVERSITY FOR TOMATO RESISTANCE TO *Pseudomonas solanacearum* IN CATIE S PLANT INTRODUCTION COLLECTION

William G. Gonzalez* and William L. Summers, Department of Horticulture, Iowa State University, Ames, IA 50011-1100
233 tomato accessions of the Central American tomato collection maintained at CATIE and 7 commercial cultivars were evaluated for resistance to 4 virulent strains of *Pseudomonas solanacearum* representing race 1 biovars 1 and 3. In general biovar 3 strains wilted seedlings faster than biovar 1 strains but by 20 days post inoculation no significant differences were noted in susceptible check ratings. Highly significant differences for disease index were noted but no line with complete resistance was found. Two CATIE accessions, 17334 and 17340, were found to be as resistant as Hawaii 7998 to all 4 strains. Accessions 17345 and MIP-CH1 were resistant to 3 strains.

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A COMPARISON OF *Pseudomonas solanacearum*-RESISTANT TOMATO CULTIVARS AS HYBRID PARENTS

William G. Gonzalez* and William L. Summers, Department of Horticulture, Iowa State University, Ames, IA 50011-1100
Seven tomato lines and their 21 hybrid populations were evaluated for their ability to resist infection by 7 virulent strains of *Pseudomonas solanacearum* representing race 1 biovars 1 and 3. In all cases the Gardner and Eberhart model III analysis found GCA values to be significant. In 5 of 7 cases SCA was

significant. In 4 cases the parent vs. cross contrast was significant. We conclude that resistance to *Pseudomonas solanacearum* is predominantly controlled by additive gene action and to a lesser degree by dominant gene effects. Hawaii 7998 was found to be resistant to all 7 strains, while Rotam 4 and Rodade were resistant to biovar 3 and one race of biovar 1 (UW 275). Venus and Saturn were resistant to 3 other biovar 1 strains. Hawaii 7998 transmitted disease resistance better than the other resistant parents but its small fruit size and indeterminate growth habit make it a poor choice for a hybrid parent.

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BREEDING SPINACH WITH MULTIPLE DISEASE RESISTANCE

T.E. Morelock, J.C. Correll, and L.P. Brandenberger, Department of Horticulture and Forestry, University of Arkansas, 316 Plant Science Building, Fayetteville, AR 72701.

Downy mildew (Blue mold) is probably the most common spinach disease in most parts of the world, and it can be a problem in the mid-South. Frequently, other diseases such as white rust and fusarium cause major crop loss. The Arkansas breeding program was initiated 25 years ago to address white rust and fusarium, as well as other diseases that destroy spinach crops. Since single gene resistance is not available for most spinach diseases, it was necessary to utilize polygenic resistance to develop varieties that are resistant to most of the common spinach diseases that occur in the Arkansas River Valley of Arkansas and Oklahoma. Highly resistant genotypes have been developed by using disease nurseries and field screening, so frequent selections are made based on the reaction to 3-4 diseases.

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VARIANCE COMPONENTS FOR LEAF AREA AND DRY WEIGHT ACCUMULATION IN GREENHOUSE TOMATOES GROWN UNDER DIFFERENT LIGHT AND NIGHT TEMPERATURE CONDITIONS

W. Alan Erb* and N. Jean Flickinger, Department of Horticulture, OARDC/OSU, Wooster, OH 44691

Two tomato inbreds (one advanced greenhouse line, P₁=Ohio ICR.9 and one frost resistant line, P₂=Ohio 4013-3) and F₁, B C₁, B C₂ and F₂ progeny were examined for growth and development during December and January to determine inheritance of biomass characters. Two-week-old seedlings from each generation (8 from the P₁, P₂ and F₁; 32 from the B C₁ and B C₂; and 64 from the F₂) developed over a 9-week period at 2 different night temperatures (17 and 12 C) and light levels (natural light and 30% shade, 5 days/week). The F₁ generation had the highest leaf area and total dry weight means followed by the B C₁ and P₁ generations. The variance components for leaf area and total dry weight accumulation were: V_e = 120,300 and 2.63; V_p = 553,618 and 12.46; V_a = 127,475 and 3.65; and V_d = 305,843 and 6.18, respectively. Both traits are highly heritable, having a broad sense heritability of 0.78 and 0.79 for leaf area and total dry weight, respectively. However, because narrow sense heritability is low, 0.23 and 0.30, respectively, improvement in biomass accumulation will be more difficult.

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PB 125

QUANTIFYING THE EFFECT OF PLUG-FLAT COLOR ON SOIL SURFACE TEMPERATURE

James E. Faust*, Hiroshi Shimizu, and Royal D. Heins, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

Surface temperature of a soilless medium in white, gray, and black plug sheets was measured to determine the value of using plug sheets of different colors to control soil temperature during seed germination and young seedling growth. Plug sheets were placed in a greenhouse set at 25°C. Soil surface temperatures were measured with fine-wire thermocouples inserted into the top 1 mm of the soil. A thermal image analyzer was used to determine the temperature variation across the plug flat. At night, soil temperature in all three

colored flats was 3°C below air temperature because of evaporation and net long-wave radiative losses to the greenhouse glass. Surface temperature of moist soil increased as solar radiation increased. Soil surface temperature in the white sheet was 6.3 and 10°C warmer than the air under solar radiation conditions of 350 and 700 W·m⁻² (about 700 and 1400 μmol·m⁻²·s⁻¹), which was 3 and 2°C cooler than soil the black and gray plug sheets, respectively. These data indicate plug sheet color influences soil surface temperature, but not as much as solar radiation does. Preventing high solar radiation during the summer is more critical than plug sheet color.

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PB 128

GROWTH OF ANNUAL SPECIES IN COCONUT COIR SUBSTRATES

Michael R. Evans*, Dept. of Horticulture, Horticulture Building, Iowa State University, Ames, IA 50011 and Robert Stamps, Univ. of Florida, Central Florida Research and Education Center, 2807 Binion Road, Apopka, FL 43708

Helianthus annuus 'Big Smile', *Tagetes patula* 'Bonanza Deep Orange' and *Pelargonium x hortorum* 'Pinto Rose' seedlings were transplanted into 12 cm (470 ml) pots containing substrates composed of 3 parts (v/v) vermiculite, 3 parts sand and 2 parts perlite. In addition, the substrates contained either 3 parts Florida peat, 3 parts coconut coir (coir), 6 parts coir or 12 parts coir, thus, resulting in 4 substrates. Dolomitic limestone, hydrated limestone, superphosphate, a microelement package and a 14-6.2-11.6 slow release fertilizer were added to the Florida peat-containing substrate. The same materials were added to the coir-containing substrates except that calcium sulfate (gypsum) was used in place of dolomitic and hydrated limestone. All materials were incorporated at rates required to obtain an initial pH of 5.5 to 5.8 and provide equal amounts of calcium, phosphorus and microelements. Data were taken 5 weeks after transplanting. Neither height, shoot fresh weights nor root fresh weights were significantly different between the substrates. *Tagetes* average heights were between 11.5 and 12.9 cm, while average shoot fresh weights were between 12.6 and 14.7 g and average root fresh weights were between 8.8 and 9.4 g. *Helianthus* average heights were between 18.4 and 19.9 cm, while average shoot fresh weights were between 29.7 and 31.9 g and average root fresh weights were between 19.6 and 22.3 g. *Pelargonium* average heights were between 11.9 and 13.4 cm, while average shoot fresh weights were between 13.8 and 15.3 g and average root fresh weights were between 3.4 and 3.7 g.

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PB 131

PROCESSED FIBER AS A SUBSTITUTE OF PEAT MOSS AND BARR FOR PRODUCTION OF ROSES

Sanliang Gu* and Leslie H. Fuchigami, Department of Horticulture, Oregon State University, Corvallis, OR 97331

'Legend' roses were grown in various potting mixtures of processed fiber (PF, a by-product of anaerobically digested dairy waste), peat moss, pumice, or bark to test the applicability of PF as a substitute of peat moss and bark. A commercial mix (peat moss and bark, 1 to 1 by volume) was used as the control. Plant appearance, growth of leaves, shoots, and flowers were the same in straight PF, commercial mix, and PF mixtures of 50% or less pumice. Plants grown in mixtures of peat moss, pumice, and bark were inferior to those in PF. This study demonstrated that PF media was better than peat moss and bark for rose production.

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PB 134

PHYSICAL ANALYSIS OF FRESH AND AGED RICE HULLS USED AS A PEAT MOSS SUBSTITUTE IN GREENHOUSE MEDIA.

Shelly D. Dueitt* and Steven E. Newman, Department of Plant and Soil Sciences, Box 9555, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS 39762.

Rice hulls, a by-product of the rice milling process, were used at various rates to substitute sphagnum peat moss in greenhouse media. Previous studies demonstrated that media containing rice hulls replacing the vermiculite fraction grew plants equal to or better than traditional peat vermiculite blends. The objective of this study was to determine if rice hulls can replace sphagnum peat moss in a greenhouse medium. Physical properties, including bulk density, total pore space, and water retention were determined in media blended with fresh or aged rice hulls, sphagnum peat moss, and vermiculite. The bulk density of the media increased with increasing levels of fresh rice hulls. The pore space in media containing both fresh and aged rice hulls decreased over time during the crop production cycle and the pH increased.

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PB 137

LIME REACTION AND pH BUFFERING IN SOILLESS MEDIA

George C. Elliott*, University of Connecticut, Dept Plant Science, U-67, Storrs, CT 06269-4067

Addition of lime to increase pH is generally essential for soilless media based on acidic organic materials. Media pH may decrease over time as the result of addition of acidic fertilizers. The objectives of this research were: to characterize reactions of conventional or finely ground lime in soilless

media; to compare resistance to acidification in soilless media amended with conventional or finely ground lime; and to evaluate, for media containing rockwool, an equation to predict H⁺ activity (HA) of binary mixtures from HA of components. Various soilless media were amended with each type of lime at rates from 1 to 16 kg m⁻³ and incubated 8 weeks at 20 C. Subsamples were removed and pH was measured in saturated slurries. Finely ground lime was about twice as effective as conventional lime in adjusting pH to 6.0 within 1 week after mixing and wetting. Neither initial nor final HA of unlimed peat-rockwool mixes could not be predicted from HA of components. Three media were amended with each type of lime, planted or left unplanted, and irrigated with fertilizer solution with and without 1.0 N H₂SO₄. Final pH of media amended with finely ground lime averaged 0.2 units lower than media amended with conventional lime. Final pH of unplanted media averaged 0.5 units lower than planted media. Final pH of media fertilized with solution containing H₂SO₄ averaged 0.6 units lower than without. Addition of H₂SO₄ to fertilizer stimulated growth of New Guinea Impatiens (*Impatiens xhybrida*).

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PB 140

MARIGOLD GROWTH IN SOILLESS MEDIA AMENDED WITH PHOSPHORUS-CHARGED ALUMINA

Yuan-ling P. Lin*, E. Jay Holcomb and Jonathan P. Lynch, Department of Horticulture, The Pennsylvania State University, University Park, PA 16802

Soilless growing media are used extensively in the greenhouse, especially for the potted plant production. Unlike soil having a phosphorus (P)-fixing ability, soilless media allows greater P leaching from the media. Leaching of excess P results in inefficient fertilizer utilization and effluent pollution. In hydroponic and sand-culture systems, alumina adsorbed with P (P-alumina) has been developed as a P source to maintain buffered P concentrations in nutrient solutions. This P-alumina has not been used with soilless media; however, it may have a potential of serving as a P source for plant growth and a P buffer to alleviate P leaching in soilless media. Marigolds were grown in soilless media (peat moss: vermiculite: sand=2:2:1, v/v/v) with P-alumina at various concentrations being substituted for sand. These marigolds were fertilized with a nutrient solution containing no additional P, while the control was fertilized with complete nutrient solution. In four cultivars of marigolds, the P-alumina treatments produced comparable or superior growth and floral production compared to plants provided with complete nutrient solutions or conventional fertilizer. 70% of applied P was leached in conventional treatments compared to only 2% in the P-alumina treatments.

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PB 163

A METHOD FOR QUANTIFYING PLANT AVAILABLE WATER-HOLDING CAPACITY AND WATER ABSORPTION POTENTIAL IN CONTAINER MEDIA UNDER PRODUCTION CONDITIONS

William R. Argo* and John A. Biernbaum, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325.

Hybrid impatiens were grown in 15 cm pots containing one of six root medium. After seven weeks, plant available water holding capacity (AWHC) was measured as the difference between the drained weight of the plant and pot after a one hour saturation and the weight of the pot when the plant wilted. Water absorption potential (WAP) was calculated as the capacity of each root medium to absorb applied irrigation water up to the AWHC and was measured at two moisture levels with top watering (two leaching fractions), drip irrigation (two leaching fractions) and flood subirrigation. Top watering moist media (initial AWHC = 35%) with leaching fractions of 30+ % was the most efficient method of rewetting media and was the only irrigation method tested to obtain WAP's of 100%. In comparison, flood subirrigation was the least efficient method of rewetting media with WAP of 27% for dry media (initial AWHC = 0%), and obtained a total WAP of 55% for moist media (initial AWHC = 23%). In media comparisons, the incorporation of a wetting agent into a 70% peat/30% bark mix at planting increased the WAP compared to the same media without a wetting agent with nine of the ten irrigation treatments.

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PB 166

DETERMINATION OF WATER UPTAKE INTO PEAT MEDIA USING LOADCELLS

Buechel, Troy M.*, David J. Beattie., and E. Jay Holcomb, Department of Horticulture, The Pennsylvania State University, University Park, PA 16802

A characteristic problem with peat moss is its difficulty in initial wetting and rewetting, especially in a subirrigation system. Wetting agents improve wetting characteristics primarily by reducing the surface tension of water. This results in a rapid, uniform movement of water by capillary rise through the growing medium.

Two methods were used to compare the effectiveness of different wetting agents: gravimetric and electrical. Ten cm pots containing peat moss were placed in a subirrigation system. The gravimetric method used a laboratory scale where pots were periodically weighed to determine the amount of water absorbed. The electrical method utilized thin beam load cells, which have strain gages bound to the surface, to determine the weight

of a suspended object. Load cells were coupled with a Campbell Scientific datalogger to collect data every minute without removing the pot from subirrigation. Because the effect of buoyancy altered the true weights, equations were generated to adjust the water uptake values. Corrected weights were used to create absorption curves for comparison of the slopes to determine which wetting agent has the fastest rate of absorption. The load cell reliably and accurately described the wetting characteristics of Peat moss and we found good agreement with the gravimetric method.

493 PB 169

VARIATION ASSOCIATED WITH TESTING PROCEDURES FOR PH AND ELECTRICAL CONDUCTIVITY OF SOILLESS POTTING MEDIA

Harvey J. Lang, Department of Horticultural Sciences, Texas A&M University, College Station, Tx. 77843-2133

Analysts of potting media for pH and electrical conductivity (EC) can be a useful tool for monitoring the nutritional status of greenhouse grown plants. This research examined the variability associated with procedures involved in the determination of pH and EC in greenhouse potting media. Three commonly used methods, the 1:5 dilution, the 1:2 dilution and the saturated media extract, were examined on several different commercial potting media. Because of the different dilution volumes used, there were significant differences in pH and EC between the three methods for all media tested. Within each method, results varied based on whether readings were taken in the slurry, solution phase, or extract, with extracts resulting in consistently higher pH, but lower EC values. There was a significant effect of medium-solution equilibration time on both pH and EC, with variability decreasing after 30 minutes of equilibration. Samples taken from the upper half of pots had higher EC readings than those collected from the bottom half of pots only on plants fertilized with N concentrations greater than 200 ppm. There was also slight variability between the different calibrated instruments used in determining pH and EC. Details of each study along with grower recommendations will be discussed.

494 PB 172

Use of Thin-Beam Load Cells as Pot Lysimeters in Greenhouse Studies

Mark V. Yelanich*, James E. Faust, Royal D. Heins, and John A. Biernbaum, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

The measurement of evaporation and transpiration from container-grown crops is labor intensive and expensive if measurements are made by periodic weighing of the plants with electronic scales. Thin-beam load cells (LCL-816G, Omega Engineering) measured with a datalogger provides a method of making continuous mass measurements over time. Four load cells were tested to determine the feasibility for use in greenhouse studies. The sensors were calibrated to an electronic scale at a range of air temperatures. The electrical signal (μV) was a linear function of mass from 0 to 816 g. The change in mass per change in electrical signal (i.e. the slope) was the same for all four load cells ($1.26 \text{ g} \cdot \mu\text{V}^{-1}$), however the absolute electrical signal (the intercept) was unique for each sensor (-246 to $+101 \text{ g}$). The effect of temperature on sensor output was unique for each sensor in terms of both the magnitude and direction of change. A two-point calibration of mass performed at a range of temperatures is required to properly use thin-beam load cells to continuously measure evapotranspiration of container-grown crops.

495 PB 175

PHOSPHORUS SUPPLY CONTROL OF BEDDING PLANT SEEDLING ROOT/SHOOT RATIO

JinSheng Huang* and Paul V. Nelson, Dept. of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

It is desirable to have a large root mass and compact shoot in the final stage of plug seedling production. Marigold 'Discovery Orange' was grown for six weeks from sowing in a hydroponic system. Hoagland's all nitrate solution was used at 0.25X for the first three weeks and 0.5X for the final three weeks. P was applied continuously in the control and was eliminated for the first one or three weeks in the two stress treatments. Weekly root and shoot dry weights indicated: a.) P stress caused an increase in root/shoot ratio with roots larger than in the control plants and b.) restoration of P after a P stress resulted in a rapid shift of root/shoot ratio back to the control level with final root and shoot weights less than in the control plants. A continuous marginal P stress or a stress near the end of seedling production is suggested. Tomato 'Marglobe' was grown for five weeks and impatiens 'Super Elfin White' for six weeks in a 3 sphagnum peat moss : 1 perlite substrate in 288 cell plug trays. Fertilizer was applied at every third watering at a zero leaching percentage. The control nutrient ratio (mM) was $5.4 \text{ NH}_4^+ \text{ NO}_3^-$: 0.5 PO_4^{3-} : 1.6 K while the low P treatments contained 0.15, 0.1, and 0.05 mM PO_4^{3-} throughout the experiment. The root/shoot dry weight ratios increased in the low P treatments. Tomato plants at 0.15 and 0.1 mM P and impatiens plants at 0.15 mM P had larger roots than the control plants. A continuous stress at 0.15 mM PO_4^{3-} appears promising.

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PB 178

AMMONIUM TOXICITY DURING PLUG SEEDLING GERMINATION AND PRODUCTION

JiWeon Lee* and Paul V. Nelson, Dept. of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Tomato 'Marglobe' seed were sown on germination paper in enclosed plastic dishes in a growth room. Ammonium was more toxic when applied as the single salt, ammonium sulfate, than when applied as part of a complete Hoagland solution. The lowest toxic ammonium levels were for the single salt 1.5 mM and for the complete solution 4.5 mM. Symptoms included reduced length of primary and particularly lateral roots, reduced numbers of root hairs, and chlorosis, distortion, and slower development of cotyledons. Tomato 'Marglobe' seedlings were also grown in 288 cell plug trays in a substrate of 3 sphagnum peat moss and 1 perlite containing no N, P, or K but amended with dolomitic limestone to pH 6.0. They were fertilized every third watering with 4 mM $\text{NH}_4^+ \text{ NO}_3^-$, 0.4 mM PO_4^{3-} , and 1.2 mM K from 15 to 28 days after sowing and at double this concentration from 29 to 42 days. A zero leaching percentage was practiced. Ammoniacal-N comprised 25, 50, or 75% of total N. There were no effects of ammonium on root or shoot weights, height or appearance of plants through this period. Plant growth was limited throughout this period by N stress in accordance with commercial practice. After 42 days N stress was alleviated by again doubling the nutrient solution concentration and applying it with every watering. Ammonium toxicity developed with symptoms of shorter plant height, general chlorosis of lower leaves, and necrosis of the base of lower leaves.

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PB 201

Growth and Media Nutrient Concentration of Poinsettia as Influenced by a Pot Cover

Mark V. Yelanich* and John A. Biernbaum, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

The evaporation of water is a major source of water loss from potted plants which can be eliminated by placing a barrier at the exposed surface of media in the pot. To better understand the effect of reducing surface evaporation on growth and media nutrient concentration, 15 cm subirrigated poinsettias were produced with and without a pot cover. Both treatments received the same quantity of fertilizer, $75 \text{ mg} \cdot \text{week}^{-1} \text{ N}$ for a total of 13 fertilizations. Uncovered pots received 12 more irrigations than pots with covers (20 vs. 32). Sixteen weeks after planting, covered plants had significantly less leaf area (2175 vs 2628 cm^2), bract area (1655 vs 2137 cm^2), height (24.1 vs 27.6 cm), fresh mass (116 vs 144 g) and dry mass (17 vs 20 g) than uncovered plants. Concentrations of N, P, K, Ca and Mg and EC (4.23 vs $2.65 \text{ mS} \cdot \text{cm}^{-1}$) were higher in the root-zone of covered plants than in uncovered plant. Covering the media surface did reduce the EC and the concentrations of N, P, K, Ca and Mg in the top layer (eg $13.47 \text{ mS} \cdot \text{cm}^{-1}$ vs $15.74 \text{ mS} \cdot \text{cm}^{-1}$) but stratification of salts to the top layer still occurred. Fertilizer salts in the top layer were shown to be less available to the plant than those in the root zone.

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PB 204

PROVIDING A CONSTANT, OPTIMUM, MOISTURE/AIR RATIO IN PLUG TRAYS DURING SEED GERMINATION AND SEEDLING GROWTH

Jack W. Buxton*, Wenwei Jia and Guoqiang Hou, Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington, KY 40546-0091

The automatic subirrigation system consists of a capillary mat placed above a constant water level in a reservoir. The optimum mat height above the water level was established by slanting a flat surface so the difference in vertical height from one end of the surface to the other was 25 cm. A ground cover providing water movement but not root penetration was placed over the mat. The capillary mat extended beyond the lowest end of the sloped surface and into the reservoir, the mat at the lowest end of the sloped surface was at the same vertical height as the water in the reservoir and remained constantly saturated. Plug trays were placed at intervals of 2.5 cm in vertical height above the water level. An average of 96-100% germination was obtained with marigold, tomato, impatiens and pepper seed in trays placed 5-7.5 cm in vertical height above the water level. These seedlings continued to develop and reached transplanting stage quicker than other trays. The rate and % germination was less in trays placed on the surface nearer to the height of the water in the reservoir. Germination in trays above 12.5 cm was greatly reduced and seed that did germinate did not develop and eventually died.

SURVEY OF SULFUR LEVELS IN GREENHOUSE IRRIGATION WATERS

Shiv K. Reddy*, Michael A. Madore and Paul A. King, Sun Gro Horticulture Inc., 177 Sanfordville Rd., Warwick, NY 10990

Irrigation water can be a "free" source of S for crops. To find out how S levels in water vary in different regions, we searched our lab database, which has analyses of water samples from all across the U.S. The results showed that 4% of the water samples had no S. About two-thirds of the waters had less than 10 ppm S, low from plant requirement point of view. Eleven percent of the waters exceeded the sufficient level of 30 ppm S. Large number of waters in the Northeast, Atlantic states including Florida and Pacific Northwest including Hawaii had low, less than 10 ppm, S. In the eastern Corn Belt states, more waters had higher, above 10 ppm, S. The data indicated that irrigation water rarely provides sufficient S for greenhouse plants.

500

PB 210

MODELING LEACHATE VOLUME PRODUCED BY TRADITIONAL CUT ROSE PRODUCTION IN GREENHOUSES: A CASE STUDY.

Dawn M. Alleman*, Robert W. Langhans, and Ellen Wells, Dept. of Floriculture and Ornamental Horticulture, Cornell University, 20 Plant Science Building, Ithaca, NY 14853

Ability to predict daily leachate volumes in greenhouse production enables strategic planning for the remediation of waste water. A case study greenhouse site (1620ft²) on Cornell campus was chosen because of the tile drainage system installed beneath. Roses 'Sonya', 'Royalty', and 'Mary DeVor' were grown in 1170ft² of bench and fertigated at bench level with automated spray nozzles. Data collection occurred over a 1.5 year period. Factors considered in modeling included: leaf area, irrigation and leachate volumes, and atmospheric / greenhouse environmental conditions (solar radiation, precipitation, temperature). Separate day and night models resulted, the night model included a condensation factor. Correlation existed between environmental factors, irrigation volume and leachate volume in the day model. In the night model a relationship between environmental factors and condensation was evident.

501

PB 213

THE EFFECT OF ALTERING THE N:S RATIO ON THE FLOWERING OF CUT CHRYSANTHEMUMS

Li-Chun Huang and Ellen T. Paparozzi* Department of Horticulture, University of Nebraska-Lincoln, Lincoln, NE 68583-0724.

previous studies indicate that there is a significant relationship between the levels of nitrogen and sulfur applied and the growth of floricultural crops. Poinsettia and roses grew well in experiments involving hydroponic solutions that contained reduced nitrogen and some sulfur.

Cuttings of *Dendranthema grandiflora* cv Dark Yellow Fuji Mefo, were grown in hydroponics with either 64, 127, or 254 ppm N in combination with either 0, 1, 2, 4, 8, 16, 32, 64 ppm S. Plants were grown unpinched and short day treatment started at the end of week 3. Data recorded included symptoms of S deficiency, date of flower initiation, stem length, flower diameter and visual observation of root growth. Color difference of leaves was measured with a chromameter. New leaves and flower heads were taken for sulfur analysis; mature leaves were used for N analysis.

Plants receiving no S showed depressed initiation and development of branch roots, delayed flower initiation, reddened lower leaves and reduced plant growth. Plants receiving some S in combination with any level of N showed good color and acceptable flower diameter and stem length.

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PB 216

GROWTH OF NEW GUINEA IMPATIENS AT THREE FERTILIZER CONCENTRATIONS AND TWO IRRIGATION REGIMES USING SOLID-STATE MICROTENSIMETERS

Timothy R. Pannkuk* and Harvey J. Lang, Department of Horticultural Sciences, Texas A&M University, College Station, Tx. 77843-2133

'Barbados' New Guinea impatiens were grown in 500 cm³ pots under drip irrigation and fertilized with solutions containing either 6, 12 or 18 mM N at two leaching fractions (0 and 30-50%). Soil moisture within the pots was characterized and controlled using electronic microtensimeters. The 0% leachate plants were automatically irrigated to container capacity when the soil tension in the pot reached 4.5 kPa, while the 30-50% leachate plants were irrigated for five minutes at a time whenever the soil tension was at or slightly

greater than 4.5 kPa. After 6 weeks, there was only a slight effect of fertilizer concentration on height, width, or leaf number of the plants. Plants grown under 0% leachate did not differ significantly in overall growth and performance than those that were leached at every irrigation. Electrical conductivity of the potting media was highest in the 0% leachate treatments (highest readings in upper one-third of the pot) and increased as fertilizer concentration increased. After 6 weeks of production, total volume of irrigation solution leached per pot ranged from 2.2 to 3.6 liters for plants grown under the 30-50% leachate treatment.

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PB 219

RECYCLING SOLUTIONS AND METHOD OF FERTILIZATION INFLUENCE GROWTH OF HYBRID GERANIUM

Patricia R. Knight, D. Joseph Eakes*, Charles H. Gilliam, and Harry G. Ponder, Department of Horticulture, Auburn University, AL 36849-5408

Seed geranium (*Pelargonium x hortorum* Bailey 'Scarlet Elite') were grown in subirrigation troughs in 10-cm pots from 25 June to 3 August 1993. Production medium was a 1 pine bark:3 peat moss:1 perlite (v:v:v) mixture. Plants were irrigated using fresh or recycled solutions and fertilized using Peter's Geranium Special 15N-6.5P-12.5K or Osmocote 14N-6.1P-11.6K. Controlled release fertilizer produced greater shoot dry weights and foliar color ratings than plants receiving water soluble fertilizer. Plants receiving a controlled release fertilizer had lower shoot N concentrations than plants receiving water soluble fertilizer. Recycled irrigation solutions reduced plant quality regardless of method of fertilization.

504

PB 242

EFFECTS OF IRRIGATION METHOD AND CONTROLLED-RELEASE FERTILIZER RATE ON LEACHATE AND GROWTH PARAMETERS OF CHRYSANTHEMUM

Thomas B. Bruning*, Michael H. Chaplin and Henry G. Taber, Iowa State University, Horticulture Department, Ames, IA 50011

Ground water contamination resulting from continuous liquid fertilization technologies is a serious problem facing greenhouse growers in the United States. Rooted *Dendranthema grandiflora* Tzvelev. cultivar 'Iridon' cuttings were transplanted into 11 cm pots filled with a 50% peatmoss and 50% perlite (v/v) media containing 0.10, 0.21, 0.42, or 0.84 g N from a controlled release 12-10-17 plus minors fertilizer deposited directly below the transplanted cutting. Pots were assigned to a top-water or subirrigation treatment.

Subirrigation reduced the nitrate leachate concentration by as much as 250 ppm as compared with top-watering. Fertilizer N rate linearly decreased plant height in both of the irrigation treatments. Final dry weight of the shoot peaked at the 0.21 g N rate in both the irrigation treatments.

505

PB 245

RADIANT COOLING LEADS TO COOLER TEMPERATURES UNDER BLACK CLOTH

Royal D. Heins* and James Faust, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

Photoperiod studies in a greenhouse usually require that the natural photoperiod be modified to increase or decrease the daylength. Modification involves using lights to extend the daylength or using some opaque material (e.g., black sateen cloth or black plastic) to shorten the photoperiod by excluding light. Air temperatures under the material can deviate from those of the surrounding air. It is common knowledge that when plants are covered by the cloth prior to sunset, solar radiation will increase the temperature under the it. It is not as widely known that temperature under the cloth will be lower than surrounding air temperature during the night. Radiant cooling of the material occurs when the greenhouse glazing material is cooler than the air temperature, resulting in cooling of the air and plants contained under the material. We have observed radiant cooling exceeding 150 W·m⁻² when glazing is cold (-7°C), resulting in a temperature reduction under the material of up to 4°C. The difference in temperature between short-day and normal- or long-day treatments can lead to incorrect conclusions about the effect of photoperiod on plant development rate. Data will be presented with a sample control system to correct the problem.

DETERMINING THE EFFECT OF CLOUD CONDITIONS ON THE VARIATION IN DAYLENGTH PERCEIVED BY PLANTS

James E. Faust* and Royal D. Heins, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

Quantum sensors were placed at plant canopy height inside and outside a glass greenhouse. Photosynthetic photon flux (PPF) was measured during September for a 3-hour period near sunrise and sunset, which were determined from US Naval Observatory Circular #171. Under clear skies, the PPF at the canopy exceeded $0.25 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ for nearly 20 minutes before sunrise through 20 minutes after sunset. Under heavy overcast, the duration was only 5 minutes before sunrise through 5 minutes after sunset. The PPF at the canopy reached $0.25 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ approximately 12 minutes later in the morning and 12 minutes earlier in the evening than it did outside the greenhouse. The length of the dark period perceived by plants in a greenhouse on September 21st (assuming plants perceive light at $0.25 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) can range from 11:37 (hr:min) during cloudy conditions to 11:15 during clear ones, a difference of 22 minutes. At 43°N latitude, the maximum difference in date of flower initiation because of an extended period of heavily overcast versus clear weather on a crop such as poinsettias would be one week since the night length during September increases by 3 minutes per day. The actual difference from year to year is probably less because a seven-day duration of heavily overcast weather is unlikely.

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PB 251

DETERMINATION OF OPTIMUM GREENHOUSE NIGHT TEMPERATURE FOR MARIGOLD SEEDLINGS BASED ON STARCH CONCENTRATION AND SEEDLING GROWTH

Guoqiang Hou* and Jack W. Buxton, Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington, KY 40546

Through control of light intensity and CO₂ concentrations, three levels of starch (low, medium and high) in marigold seedlings existed at sunset. The range in starch concentration represented that encountered under average greenhouse conditions. For each starting starch concentration, an optimum temperature was initially determined based on first and second order reactions on the corresponding starch decline curve. Every day, during seedling growth in the greenhouse, the starch concentration at sunset was predicted based on primarily the quantity of light received throughout the day; the night temperature was adjusted to the predicted optimum night temperature setting. Based on these studies a significant improvement in seedling growth can be achieved with significantly less heating cost.

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PB 254

EFFECT OF CARBON DIOXIDE ENRICHMENT ON PRODUCTION AND QUALITY OF GREENHOUSE 'ROYALTY' ROSES PRODUCED IN COASTAL CENTRAL CALIFORNIA

Steven A. Tjosvold, University of California Cooperative Extension, 1432 Freedom Blvd., Watsonville CA 95076

The atmosphere of commercial greenhouses were enriched to 1200 $\mu\text{l}\cdot\text{l}^{-1}$ carbon dioxide 1 hour before sunrise and maintained until ventilation was necessary to cool the greenhouse and again anytime the greenhouse vents were closed in the daytime. Enrichment was only possible, on average, for 5 daylight hours in the winter and less in the warmer months. In the first 10 month experiment, total production was not different in carbon dioxide enriched greenhouses. Stem lengths of harvested flowers were generally longer in the enriched greenhouses, particularly in the winter months. In the second 10 month experiment, total production was again not different in carbon dioxide enriched greenhouses, however, stem length was only slightly longer in the winter months. Dry weights of flower buds, stems and leaves increased slightly but only in winter months.

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PB 257

SPECTRAL FILTERS AND GROWING SEASON INFLUENCE GROWTH AND CARBOHYDRATE METABOLISM OF CHRYSANTHEMUM

Nihal C. Rajapakse and John W. Kelly, Department of Horticulture, Clemson University, Clemson, SC 29634-0375.

The interaction of light quality and growing season on growth and carbohydrate metabolism of chrysanthemum was evaluated using 6% CuSO₄ and water as spectral filters. Light transmitted through the CuSO₄ filter significantly reduced plant height and internode length compared to control plants regardless of the season. Light transmitted through CuSO₄ filters delayed flowering. Total number of flowers was not affected but plants grown under CuSO₄ filter had smaller flowers than those grown under the control filter. Light transmitted through CuSO₄ filter reduced leaf and stem soluble sugar and starch concentrations regardless of the growing season. However, the magnitude of reduction was greater in

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spring than in fall-grown plants. Stems of fall-grown plants had more starch deposition than spring-grown plants under both filters. The reduction of leaf and stem carbohydrate content (per organ basis) was greater than that of concentrations due to reduced stem elongation and total dry matter accumulation. Filters with specific spectral characteristics can be used as alternative means of controlling height and producing compact plants in the greenhouses regardless of the growing season. However, flowering should be evaluated with individual flower crops as flowering response may interact with the quality of light and growing season.

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PB 260

COMPARISON OF FIELD AND SHADEHOUSE MICROCLIMATE FACTORS RELATED TO EVAPORATION AND CROP TRANSPIRATION

Robert H. Stamps, Central Fla. Res. and Educ. Center, Inst. of Food and Agr. Sci., Univ. of Fla., 2807 Binion Road, Apopka, FL 32703

Microenvironmental conditions in a shadehouse covered with shade fabric designed to exclude 70% of incoming light were monitored and compared to those in an adjacent field to quantify differences related to plant water use. Radiant flux density and photosynthetic, photon flux inside the shadehouse varied seasonally between about 18% to 28% of outside values. During the day, leaf and air temperatures around the crop canopy were generally lower and relative humidities higher inside the shadehouse than outside. Leaf-to-air vapor pressure gradients inside the shadehouse averaged about half those outside. Wind run inside was <10% of wind run outside. Differences between reference ET (ET_o) values, calculated using Penman's equation), inside and outside the shadehouse were greatest during summer months. Outside evaporative pan (E_{pan}) water losses ranged from 205 mm in July to 95 mm in Nov. For the same months, E_{pan} losses inside were about 80% lower. Monthly ET_{actual}, as determined for *Rumohra adiantiformis* growing in lysimeters in the shadehouse, ranged from around 40% to 80% of inside E_o.

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PB 283

SEASONAL COMPARISONS OF THREE ROSE (ROSA HYBRIDA L.) CULTIVARS

Virginia S. Story*, Douglas A. Hopper, and Troy T. Meinke, Department of Horticulture, Colorado State University, Fort Collins, CO 80523

Two-year-old *Rosa hybrida* L. 'Royalty', 'Emblem', and 'Samantha' plants were pinched 20 Oct. and 28 Dec. 1992 for Christmas and Valentine's day crops. At 10 and 25 days after pinch, and at flowering, 5 shoots from each bench location were destructively sampled for leaf (node) number, stem diameter, stem length, and fresh and dry weights of stem, leaves, and flower bud. Time to visible bud, to color, and to flower from pinch were also recorded.

Results were tabulated; an analysis of variance showed that the three rose cultivars produced flowers which were not significantly different within crops but were different between seasonal crops. The Christmas 'Royalty' crop produced more flowers (but also more blind shoots) than did the Valentine's Day crop. Days to flower, stem diameters, and stem lengths were similar within and between crops for all cultivars. Total fresh and dry weights for all three cultivars tended to be greater for the Valentine's Day crop than for the Christmas crop. The seasonal photosynthetic photon flux (PPF) variation may account for these differences.

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PB 286

EFFECTS OF INTERIOR PLANTS ON RELATIVE HUMIDITY AND AIR-BORNE PARTICULATE MATTER IN INDOOR ENVIRONMENTS

Virginia I. Lohr, Georgia K. Goodwin, and Caroline H. Pearson-Mims*, Department of Horticulture and Landscape Architecture, Washington State University, Pullman, WA 99164-6414

Foliage plants were added to different environments, including an office and a computer lab. Relative humidity and air-borne particulate matter were monitored in the presence and absence of the plants. When the relative humidity was low, the addition of plants increased the relative humidity slightly, but significantly, over that when no plants were present. Particulate matter accumulation was not increased in the presence of plants. Some have hypothesized that the growing medium could be a source of increased particulates when plants are used indoors. Some of our experiments used self-watering containers, irrigated from below, resulting in very dusty conditions in the top of the container. If the growing medium could contribute to increases in particulate matter, we should have detected it in this study.

33 POSTER SESSION 6 (Abstr. 513-529)

Fruits/Nuts/Berries: Breeding and Genetics

513

PB 441

SUSCEPTIBILITY OF APPLE ROOTSTOCKS TO CROWN GALL:

COMPARISON OF INOCULATION ABOVE AND BELOW SOIL LEVEL
E.W. Stover* and C.S. Walsh¹ Dept. of Hort. Sci., Cornell U., P.O. Box 727,
Highland, NY 12528. ¹Dept. of Hort., U. of Maryland, College Park MD 20742

Trees of each of five rootstock genotypes (M.7a, M.9, M.26, MM.111, Mark,) were inoculated above and below ground with three strains of *Agrobacterium tumefaciens*. These were compared to controls that were uninoculated or inoculated with sterile deionized water. All rootstocks tested were quite susceptible to crown gall, but M.9 and Mark were consistently among the most susceptible genotypes. Percent of inoculated sites forming galls above ground ranged from 43% in M.7a to 77% in M.9 and the mean size of galls that formed ranged from 3.7 mm in M.26 to 7.7 mm in M.9. All rootstocks except M.9 formed galls at a higher percentage of inoculated sites that were below ground. Percent of below ground inoculations forming galls ranged from 67% in MM.111 to 100% in Mark while mean size of galls underground ranged from 4.2 mm in MM.111 to 15.3 mm in M.9. The proportion of inoculated sites forming galls below ground in M.7a was twice as high as in above ground sites For rootstock X strain means, each measure of crown gall susceptibility above ground was significantly correlated with corresponding below ground data at the 0.01 level. to three rootstocks, some trees inoculated with sterile deionized water also produced apparent galls at sites below the soil line (100% in Mark, 60% in M.7a, 22% in M.26) although none of the above ground control inoculations produced galls. Uninoculated controls showed no gall formation.

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PB 444

VIRULENCE OF *ERWINIA AMYLOVORA* STRAINS ON PEAR

David M. Hunter* and W. Gordon Bonn, Agriculture Canada Research Station, Harrow, ON Canada NOR 1G0

The virulence of six strains of *Erwinia amylovora* used in combination for screening fire blight resistance of pear seedlings and advanced selections from the Harrow pear breeding program was evaluated by inoculating a standardized suspension (10^8 cfu/ml) of the six strains individually and in combination into actively growing shoot tips and measuring the lengths of the diseased shoots six weeks later. Three cultivars provided a range of resistance to fire blight: 'Bartlett' was susceptible, HW-605 ('Seckel' x NJ-6) was moderately resistant, while 'Kieffer' was resistant. On 'Bartlett', one strain was consistently more virulent than the combination, while on HW-605, two strains were consistently more virulent than the combination. One strain was consistently less virulent than the combination on both 'Bartlett' and HW-605. No strain was consistently more or less virulent than the combination when inoculated into 'Kieffer'. Lesion lengths were greater in the susceptible cultivar 'Bartlett' than in either HW-605 or 'Kieffer'. These results suggest that a combination of strains of *E. amylovora* is appropriate for screening for fire blight resistance in pear genotypes.

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PB 447

'POTOMAC': A NEW FIRE BLIGHT-RESISTANT PEAR CULTIVAR

Richard L. Bell*, T. van der Zwet, USDA-ARS, Appalachian Fruit Research Station, 45 Wiltshire Road, Kearneysville, WV 25443, C.K. Chandler and J.C. Scheerens, Dept. of Horticulture, The Ohio State University, Wooster, OH 44691

'Potomac' has been released as a new pear cultivar which combines a high level of resistance to fire blight with excellent fruit quality. Selected from a cross of 'Moonglow' x 'Beurre d'Anjou', it was tested under the seedling number, US 62537-048. Fruit are ovate-pyriform in shape, and average 73mm in diameter. Skin color is light green and the finish is glossy at harvest maturity, which occurs about 2 weeks after 'Bartlett'. Flesh texture is moderately fine, buttery, and juicy; grit cells are small and limited to a thin layer under the skin. Flavor is subacid, with mild aroma, and similar in character to 'Beurre d'Anjou'. Fruit may be ripened after harvest without cold storage, but 'Potomac' is more susceptible to superficial scald than Beurre d'Anjou if stored for more than eight weeks. The tree is moderately vigorous. Yield and precocity are moderate. Fire blight resistance is greater than that of 'Seckel', with a high degree of resistance in both shoots and blossoms. The cultivar is recommended for home orchards and limited commercial trial.

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PB 450

USE OF A BOUNCEMETER TO SHOW VARIETAL DIFFERENCES IN PEACH FRUIT QUALITY DURING RIPENING

W.R. Okie *, USDA-ARS S.E. Fruit & Tree Nut Research Lab., 111 Dunbar Rd., Byron, GA 31008

Peach breeders need rapid, non-destructive methods to rate fruit quality changes after picking in order to select genotypes that can be delivered to the consumer with the maximum quality. Changes in ground color and firmness over time can be quantified by use of a bouncemeter (which measures coefficient of restitution) in conjunction with a colorimeter. During 1991 and 1992, the ripening patterns of over 100 peach and nectarine varieties and selections were measured, allowing comparisons between different genotypes. Ten fruit, picked when firm ripe, were measured both before and after storage for 5 days at 5°C followed by 2 days at 20°C. Soluble solids (%) for each fruit were then measured with a refractometer, followed by determination of titratable acidity on 2 pooled samples. In general ground color changed from green to yellow and firmness decreased over time, but genotypes varied widely in the relationship of ground color and firmness. There also appeared to be differences in rates of change of these parameters.

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PB 453

ULTRASTRUCTURAL SURFACE CHARACTERIZATION OF FRUIT OF PEACH PLANT INTRODUCTION 133984.

Michael A. Creller* and Dennis J. Werner, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Surface morphology of peach [*Prunus persica* (L.) Batsch] Plant Introduction 133984 ('Marina') differs from standard peach and nectarine clones. Scanning electron microscopic examination of 'Marina', a standard peach ('Contender'), and a nectarine ('Sunglo') was conducted. At anthesis, 'Marina' ovaries were glabrous, similar to 'Sunglo' nectarine. Fruit of 'Contender' were fully pubescent at anthesis. Examination of 'Marina' fruit two weeks after anthesis revealed the presence of both pubescent and glabrous sectors on the fruit surface. At fruit maturity, most of the fruit surface of 'Marina' was covered with pubescence, but trichome density was considerably less than 'Contender' peach. Trichome morphology of 'Marina' differed from that of 'Contender'.

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PB 456

INHERITANCE OF PROCUMBENT GROWTH CHARACTERISTICS AMONG HYBRIDS OF 'CIPO' SWEET ORANGE

Kim D. Bowman U.S. Horticultural Research Laboratory, 2120 Camden Road, Orlando, FL 32803

Citrus tree size and growth form are important traits that can be influenced by the genotype of both scion and rootstock cultivars. However, there have been very few reports of size or growth habit traits within Citrus or sexually compatible genera that might be transmitted genetically in breeding programs. A procumbent growth habit has been described for 'Cipo' (*Citrus sinensis* [L.] Osbeck), a unique sweet orange cultivar maintained in the USDA germplasm repository. Sexual hybrids were produced between this selection and four related species, and these progenies were evaluated for two distinct traits associated with the unusual growth habit of 'Cipo'. Inheritance of both drooping petiole and horizontal shoot growth were observed among the 'Cipo' hybrids. Investigations are continuing on these four populations to verify segregation patterns and identify individuals possessing favorable combinations of growth habit with other desirable tree characteristics.

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PB 477

INHERITANCE OF CONTORTED GROWTH HABIT IN HAZELNUT

Shawn A. Mehlenbacher and David C Smith*, Department of Horticulture, Oregon State University, Corvallis, OR 97331-7304

The contorted hazel, *Corylus avellana* 'Contorta', is an ornamental tree prized for its grotesquely twisted trunk and branches. 'Contorta' was discovered in a hedgerow in England about 1863 and has been commercially propagated by layerage or graftage because it was thought to not breed true from seed. We investigated the inheritance of contorted growth habit in the course of our work breeding hazelnuts. Crosses between normal growth habit cultivars and 'Contorta' produce all normal seedlings. Sib matings of compatible normal seedlings of 'Contorta' produce offspring in the proportion of 3 normal: 1 contorted. The backcross of a normal 'Contorta' seedling to 'Contorta' gives progeny in the ratio of 1 normal: 1 contorted, indicating control of the trait by a single recessive gene.

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- 520 PB 480
USE OF TYVEK HOUSEWRAP FOR POLLINATION BAGS IN BREEDING OF HAZELNUT.
David C Smith* and Shawn A. Mehienbacher, Department of Horticulture, Oregon State University, Corvallis, OR 97331-7304
Tyvek housewrap (Du Pont, Wilmington, Delaware), an air-infiltration barrier for use in house construction, has been put to a novel use for making pollination bags for breeding hazelnuts (*Corylus avellana* L.). Bagged flowers are used in making crosses and incompatibility testing and remain receptive for up to 3 months. Tyvek has outperformed paper and plastic materials we have tried in terms of durability and cost. Tyvek is a spun-bonded, nondirectionally oriented film of highdensity polyethylene fibers that is permeable to water vapor and air, but is water resistant and pollen-proof, and can be made into bags of any size needed.
- 521 PB 483
RESISTANCE TO EASTERN FILBERT BLIGHT IN *CORYLUS* SPECIES AND INTERSPECIFIC HYBRIDS
Glare J. Coyne* and Shawn A. Mehlenbacher, Dept. of Horticulture, 4017 ALS, Oregon State University, Corvallis, OR 97331
Eastern filbert blight (EFB) (*Anisogramma anomala*) is a serious disease of the European hazelnut (*Corylus avellana*). A single dominant gene for immunity to EFB from *C. avellana* 'Gasaway' is being combined with good nut and kernel traits using a modified backcross approach. Additional sources of resistance would be highly desirable. Clones and seedlings of six other species (*C. columa*, *C. comuta*, *C. heterophylla*, *C. sieboldiana*, *C. amercana*, and *C. jacquemontii*) and a few interspecific hybrid selections were screened in the greenhouse to identify new sources of resistance. *C. jacquemontii* seedlings and *C. columa* clones were highly susceptible. *C. comuta*, *C. hetemphylla*, and *C. sieboldiana* clones were resistant, as were 86% of the *C. americana* seedlings tested. Five *C. americana* x *C. avellana* hybrids from New York were resistant under field conditions. One of four *C. comuta* x *C. avellana* and two of three *C. hetemphylla* x *C. avellana* hybrids were resistant.
- 522
THE EVALUATION OF COLD HARDINESS IN HAZELNUT.
Annie M. Chozinski* and Shawn A. Mehlenbacher. Dept. of Horticulture. Oregon State Univ., Ag and Life Sci. 4017. Corvallis, OR 97331
Laboratory freezing tests were conducted for two consecutive winters to determine the cold hardiness (CH) of hazelnut trees (*Corylus*). Thirty-six different genotypes were evaluated. LT₅₀s were calculated for female inflorescences, catkins and vegetative buds. Most (> 70%) female flowers achieved their maximum hardiness in January. Nearly half (45 %) of all female flowers had LT₅₀s between -38.0 C and -21.4 C. Catkins were most hardy in December after which they began to elongate and lose their CH. In December, catkin CH ranged from -33.0 to -13.4 C. Vegetative buds were more hardy than both female flowers and catkins. LT₅₀s ranged from, -40.0 to -26.8 C with 95% achieving maximum CH in January. More than half (54%) had LT₅₀s between -30.0 and -20.0 C. In summary, vegetative buds are more CH than female buds which in turn are more hardy than catkins.
- 523 PB 489
INCORPORATION OF USEFUL TRAITS FROM NATIVE ALMOND SPECIES INTO CULTIVATED ALMOND VARIETIES.
II. GENE INTROGRESSION.
Thomas M. Gradziel* and Dale E. Kester, Department of 'Pomology, University of California, Davis, CA 95616
Breeding lines have been developed incorporating introgressed genes from three native almond species *Prunus fencliana*, *Prunus webbii* and *Prunus argentea*. Selected traits fertility and autogamy, late bloom, smaller tree size, early nut maturity, improved cropping potential, and a well-sealed shell (endocarp) with high kernel/shell crack-out percentages. Fertility barriers, while present were easily overcome though linkage to introgressed genes with undesirable phenotypes remains an important obstacle to commercial use. Current breeding results, however, support a general conclusion that the wide diversity present within the range of species related to the cultivated almond (*Prunus dulcis*) provides an valuable gene pool for variety improvement.
- 524
SEVERITY OF BOTRYTIS BLOSSOM BLIGHT DAMAGE ON BLUEBERRY CULTIVARS AND SELECTIONS
Chad Finn*, Gina Koskela, and Joseph Snead, USDA-ARS, Northwest Center for Small Fruit Research; Oregon State University- North Willamette Res. and Educ. Center; and USDA-ARS National Clonal Germplasm Repository, c/o 3420 NW Orchard Ave. Corvallis, OR 97330
Infestations of Botrytis blossom blight (*Botrytis cinerea*) can reduce yields in commercial blueberry fields in the Pacific Northwest. In 1993, environmental conditions during blueberry flowering were ideal for the development of Botrytis. Individual plants were evaluated in a replicated highbush blueberry culture/advanced selection trial (42 clones, 5 reps, 3 plants) in Aurora, Ore. Each plant was evaluated for damage due to Botrytis using a subjective scoring system (1= all flower clusters on plant appear blighted, 5= many blossoms blighted, 9= no blossoms blighted). Many clones showed very little injury. The following clones showed the greatest injury, in decreasing order of severity, NC 2678, 'Bluechip', 'Bounty', G-805, 'Nelson', G-224, 'Berkeley', 'Sierra', and 'Bluegold'. In addition, Botrytis damage was scored on the field collection of *Vaccinium* at the National Clonal Germplasm Repository. Data from this nonreplicated study will also be presented.
- 525 PB513
SEED SIZE OF SELECTED *RUBUS* SPECIES
Kim E. Hummer* and Derek N. Peacock, USDA-ARS NCGR, 33447 Peoria Road, Corvallis, OR 97333, USA
Recent USDA plant collecting expeditions to Ecuador; the People's Republic of China, and within North America, have obtained a number of lesser known wild *Rubus* species. These, and additional species, are preserved as seedlots with some plant representatives, at the USDA-ARS National Clonal Germplasm Repository-Corvallis. In this study, the seed size of 40 *Rubus* species was measured and contrasted. The average weight of the largest-seeded species of the study group, *R. megalococcus* Focke, an Ecuadorean blackberry, was 24.2 mg; European blackberry, *R. procerus* Muller, was 3.0 mg. The average weight of other European and North American blackberry and raspberry seed ranged from 2.7 to 1.3 mg. Asian raspberry species tended to be the smallest, ranging from *R. coreanus* Miq. at 1.2 mg to *R. eustephanus* Focke ex Diels at 0.3 mg. Several of the smaller seeded Asian species such as *R. formosensis* Kuntze, *R. minusculus* A. Leveille & Vaniot, *R. hirsutus* Thunb., and *R. eustephanus* had many drupelets, which may be a heritable trait to benefit yield through breeding for increased fruit size.
- 526 PB 516
RUBUS SEED SENSITIVITY TO SODIUM HYPOCHLORITE
Derek N. Peacock* and Kim E. Hummer, USDA-ARS NCGR, 33447 Peoria Road, Corvallis, OR 97333, USA
During research to develop a new germination protocol for *Rubus* being conducted at the National Clonal Germplasm Repository in Corvallis, we observed mixed responses to sodium hypochlorite (NaOCl) as a seed scarifying agent. For *R. parviflorus* Nutt., scarification with NaOCl resulted in 34% germination. Fewer than 1% of the seedlings showed any negative effects after exposure to 2.6% NaOCl for 24 hours. But in *R. ursinus* Cham. & Schldl., *R. multibracteatus* A. Leveille & Vaniot, *R. swinhoei* Hance, and *R. setchuenensis* Bureau & Franchet, the percentage of injury observed ranged from 40% to 100%. In these cases, although embryonic tissue did not appear necrotic, the radicle and plumule failed to elongate after emergence. The epicotyl or primary leaves did not develop, and the radicle failed to form root hair. The cotyledons, apparently unaffected, opened and were a healthy green. NaOCl did not kill the embryo, but deterred development of the embryonic axis. As a result of the NaOCl scarification the cotyledons expanded yet the seedlings eventually died.
- include self -
527 PB 519
TOBACCO STREAK VIRUS PRESENCE IN *RUBUS URSINUS* COLLECTED FROM THE PACIFIC NORTHWEST
Chad Finn* and Robert Martin, USDA-ARS, NW Center for Small Fruit Research and AgCanada, Vancouver Research Station. c/o 3420 NW Orchard Ave. Corvallis, OR 97330
Cuttings from *Rubus ursinus* Cham. & Schlecht, the trailing blackberry, were collected in Oregon, Washington, and British Columbia from 21 sites. The cuttings were rooted and placed in pots in the greenhouse. After the plants began to grow, leaves were harvested for ELISA testing using standard procedures. Each sample represented three

clones from a site. Plants from 18 sites were represented by five samples and two sites were represented by three samples. None of the samples tested positive for the presence of raspberry bushy dwarf virus or tomato ringspot virus. Forty-four percent of the samples tested positive for tobacco streak virus. Only 33% of the sites on the Pacific coast tested positive for tobacco streak, whereas, 100% of the Cascade Mountain sites and 88% of the sites in the coastal range type environment tested positive. The only site in the Willamette Valley had no positive tests. With one exception, all of the sites that tested negative for the virus were also low elevation sites 0-90 m.

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PB 522

WILD *RIBES* OF THE PACIFIC NORTHWEST

Wes Messinger¹, Kim Hummer², and Aaron Liston¹, 'Botany Dept., Oregon State University, Corvallis, OR 97331 and 'USDA-ARS National Plant Germ Plasm Repository, 33447 Peoria Road, Corvallis OR 97333.

The Pacific Northwest boasts a remarkable diversity of wild currants and gooseberries (*Ribes*). Of nearly 150 species worldwide, 34 occur in the region. All but two infrageneric taxa are represented, including close relatives of the black currants, red currants, and cultivated gooseberries. High ecological diversity parallels this taxonomic diversity: a *Ribes* species occurs in nearly every terrestrial habitat, from sea level to above treeline, and from swamp to desert. This diversity is a valuable source of agronomically important genes for the plant breeder. In addition, wild *Ribes* represent a relatively unexplored source of ornamental shrubs. Habit and habitat of a number of species of interest are described and illustrated. An annotated list of species, subspecies, and varieties native to the Pacific Northwest is presented with discussion of taxonomic proximity to Cultivated varieties, range, natural habitat, and ornamental potential.

529

PB 525

DETERMINING RESISTANCE IN STRAWBERRY TO ANTHRACNOSE USING TOXINS PRODUCED IN FUNGUS CULTURE

John L. Maas¹, Barbara J. Smith², and Gene J. Galletta¹ U.S. Dept. of Agriculture, 'Fruit Laboratory, Beltsville, MD 20705 and 'Small Fruit Research Station, Poplarville, MS 39470.

We have determined in tests conducted both at Beltsville and Poplarville that several strawberry isolates of *Colletotrichum acutatum*, *C. gloeosporioides* and *C. fragariae* produce toxin-like compounds in culture. Crude culture filtrates (CFI) elicited general and specific responses in tomato and strawberry plants. Tomato plants initially were used because they are highly responsive to toxins in general, whereas the reaction of strawberry plants apparently is greatly affected by environmental and nutritional growing conditions of the test plant. Toxin symptoms included leaf chlorosis and wilting, leaf midvein darkening, and plant death when CF was applied to leaves or if seedlings or petioles were immersed into CF. Juvenile tissues appear to be more susceptible to the effects of the toxins than mature tissue. No differences in response to culture filtrates were apparent among those from the *Colletotrichum* isolates. The putative toxins appear to act differentially with susceptible or resistant strawberry germplasm.

34 POSTER SESSION 7 (Abstr. 530-551) Vegetables: Culture and Management

530

PB 002

SIZE DISTRIBUTION OF PICKLING CUCUMBER FRUIT DURING THE HARVEST PERIOD.

Craig R. Department of Horticulture and Forestry, PS 316, University of Arkansas, Fayetteville, AR 72701

Three different types of pickling cucumber (*Cucumis sativus*) were planted in the field with 4 replications in a randomized complete block design. The cultivars selected were standard leaf, "little leaf", and standard X "little leaf" crosses. The growth of populations of cucumber fruit from each of the three types was measured over a 14 day period which included the optimum harvest date for

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mechanically harvesting the fruit. A plant sample one m² was randomly selected, the population of fruit diameter and length in each sample was measured daily. The standard leaf types were the first to reach a harvest date. The standard X "little leaf" crosses were next, followed by the "little leaf" cultivar. The differences in days to harvest could be 14 days or more between the standard and "little leaf" types. The distribution of fruit by number and volume will be presented. Using this information a harvest date for maximum economic return can be predicted for each of the cultivars.

531

PB 005

PLANT POPULATION AFFECTS THE YIELD AND FRUIT SIZE OF 'SUPERSTAR' MUSKMELON

W.D. Scott and E.T. Maynard*, Dept. of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907-1165

Muskmelons (*Cucumis melo* L. cv. Superstar) were grown at two between-row spacings (1.5 m or 2.1 m) and four in-row spacings (0.6, 0.9, 1.2, or 1.5 m), corresponding to populations from 3074 to 10763 plants ha⁻¹, to determine the influence of row spacing and population on melon growth and yield. The study was conducted at two sites in 1993, one in northern and one in southern Indiana. Numbers of flowers and early season vine growth were not significantly different between treatments. In southern Indiana, the number of fruit harvested per plot increased as in-row spacing decreased; means ranged from 5.2 fruit plot⁻¹ for 0.6 m in-row spacing, to 4.7 fruit for 0.9 m in-row spacing, 3.9 fruit for 1.2 m in-row spacing, and 3.3 fruit for 1.5 m in-row spacing. Harvests were significantly earlier for the 0.6 m in-row spacing. Mean melon weight was significantly greater for 1.5 m in-row spacing, averaging 4.1 kg, compared to 3.8, 3.7, and 3.7 kg for 0.6, 0.9, and 1.2 m in-row spacings, respectively. Between-row spacing did not affect number or weight of melons. There were no significant interactions between in-row and between-row spacings.

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PB 008

DEVELOPMENT OF ROOT RESTRICTION STRESS IN WATERMELON TRANSPLANTS

Aimin Liu and Joyce G. Latimer*, Department of Horticulture, University of Georgia, Georgia Station, Griffin, GA 30223

Seeds of 'Mirage' and 'Starbrite' watermelon [*Citrullus lanatus* (Thunb.) Matsum. and Nakai] were sown in TODD planter flats with root cell volumes of 20, 28, 39, 49, or 83 cm³. Plants were harvested for growth measurement at 5, 10, 15 and 20 days after seeding (DAS). Data were regressed over root cell volume for each harvest date. The effect of root volume restriction (RVR) was determined by comparing the slopes of the regression lines. All measurements of growth increased with increasing root volume at each harvest date. Generally, the slopes of all regression lines increased with each successive harvest, i.e., plant growth was limited more in the smaller root volumes than in larger volumes at each successive harvest. The greatest increase in the slopes of the regression lines occurred between 10 and 15 DAS for most measurements of both cultivars. This indicates that RVR became significantly more limiting to seedling growth after 10 DAS which corresponded to the second to third true-leaf stage.

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PB 011

SCREENING OF POLYETHYLENE AND ORGANIC MULCHING FILMS FOR USE IN MELON PRODUCTION IN THE LOWER RIO GRANDE VALLEY

L.P. Brandenberger* and R.P. Wiedenfeld. Texas A&M University Research and Extension Center, 2401 E. Hwy 83, Weslaco, Tx 78596

Bare soil, 13 different polyethylene mulching films, and K-Mulch kenaf paper film were compared to one another for use in early spring production of cantaloupe melons. The mulching treatments were applied to the top of raised beds spaced 200 cm apart in late January and seed of the cantaloupe variety Cruiser were planted in early February. Treatments were replicated five times in a complete randomized block design. Plots were irrigated throughout the season utilizing a drip irrigation system. Crop responses to mulches throughout the growing season were determined by measuring vine growth, fruit yield, Fruit quality and earliness. Mulch tensile strength was determined throughout the season, and ease of cleanup and disposal were evaluated after the growing season. Differences were recorded for treatments particularly regarding ease of cleanup.

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QUANTIFICATION OF THE SPECTRAL PROPERTIES OF POLYETHYLENE MULCHES WHICH INFLUENCE SOIL TEMPERATURE AND BELL PEPPER PRODUCTION

Heather Hatt Graham*, Plant Science Department, Box 3AE, New Mexico State University, Las Cruces, NM 88001, Margaret J. McMahon, Department of Horticulture, 2001 Fyffe Court, The Ohio State University, Columbus, OH 43210, Dennis R. Decoteau, Department of Horticulture, Box 340375, Clemson University, Clemson, SC 29634, and Dale E. Linvill, Department of Agricultural and Biological Engineering, Box 340357, Clemson University, Clemson, SC 29634

Commercially available polyethylene mulches were evaluated for their influence on spectral properties (absorption, reflection, and transmission) and soil temperature during the growing season. Vegetative growth and yield of bell pepper (*Capsicum annuum* cv. Keystone Resistant Giant No. 3) plants were evaluated for each mulch. Black plastic had the greatest absorption (95%) of photosynthetic photon flux (PPF; 400-700 nm). White plastic had the greatest reflection (6575%) of PPF and blue (400-500 nm) light. The Alor selective mulch had the greatest reflective far-red/red ratio (730-740/640-650 nm) of light. Clear plastic had the greatest transmission (90%) of PPF and blue light. Soil temperature was coolest under the white mulch (32 C) and warmest under the clear mulch (52 C) when measured at maximum soil temperature in the early afternoon (1400 to 1800 hrs). Vegetative growth and yield were greatest for plants grown on the white mulch treatment and lowest for plants grown on the clear mulch treatment.

yield was increased by the mulch and mulch plus rowcover treatments, while the rowcover and control treatments yielded the least ($P < 0.05$). Soil temperature at 10 cm depth varied between 1° to 2°C only under the different treatments. Air temperature under the rowcover exceeded 35 to 40°C on many days, hence causing fruit setting problems and resulting in reduced early yield under the rowcover. Our results show that earliness is enhanced by black plastic mulch, while the rowcover alone can have a negative effect on yield. Time of rowcover removal above the mulch warrants further research.

SOIL BEDDING TREATMENTS INFLUENCE PEPPER PLANT ANCHORAGE

J.E. Motes*, M.D. McCullough and B.A. Kahn, Department of Horticulture and Landscape Architecture, Oklahoma State University, Stillwater, OK 74078

A problem associated with machine harvesting of pepper (*Capsicum annuum* L.) with a stripper-type harvesting mechanism is plant uprooting. Four soil bedding treatments were compared for effects on uprooting force of Chile and paprika direct field seeded at Bixby, Okla. in 1992 and 1993. Bedding treatments were: 1) no-bed; 2) no-bed with 5 cm of soil hilled to the bases of plants; 3) bedded preplant but bed not maintained throughout the growing season; and 4) bedded preplant and bed maintained throughout the growing season. At harvest plants were cut off 10 cm above the soil surface and uprooting force determined using a wire cable puller, spring scale, and a lever based on a fulcrum. Chile uprooting force was significantly influenced by bedding treatments only in 1993. Paprika uprooting force was influenced in both years. In three of the four studies, bedding treatments 2 and 4 produced plants more strongly anchored than treatments 1 and 3.

SINGLE-UNIT BROCCOLI AS AN ALTERNATIVE CASH CROP

Lewis W. Jett*, Ronald D. Morse, and Charles R. O'Dell, Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0327.

Consumer attitudes and preferences towards fresh market broccoli (*Brassica oleracea* L. Group *Italica*) are changing. Consumers desire large-head broccoli with more florets per unit weight, which we term single unit broccoli. Single unit broccoli could be field established by transplanting, alleviating the problems of poor stand establishment encountered with direct-seeded broccoli in the Southeast. The objectives of this research were to determine the feasibility of producing single unit broccoli and the optimal plant arrangement and spacing to maximize the yield of single unit broccoli. Two spatial arrangements (single vs. twin row) and five plant densities (10.8, 7.2, 5.4, 4.3 and 3.6 plants/m²) were examined in 1990 and 1991 for production of single unit broccoli. Spatial arrangement had no significant effect on any measured variable, although the twin row arrangement resulted in less plant damage with each multiple harvest. For exclusive production of high quality, single unit broccoli with high yields of marketable florets, a planting density of 3.6 plants/m² (46 cm within row spacing) should be used in a twin row arrangement.

RESPONSE OF PEJIBAYE TO HERBICIDES AND BLACK POLYPROPYLENE MAT DURING ESTABLISHMENT IN HAWAII.

Joseph DeFrank* and Charles R. Clement, Dept. Horticulture, University of Hawaii, 3190 Maile Way, Honolulu, HI 96822.

Pejibaye (*Bactris gasipaes*, Palmae) is being evaluated for heart of palm production in Hawaii. Yields and weed control were evaluated in response to: oryzalin (4.5 and 9.0 kg ai/ha), oxyfluorfen (0.6 and 1.2 kg ai/ha), paraquat (1.2 and 2.4 kg ai/ha) and woven black polypropylene mat. Four open-pollinated progenies from the Benjamin Constant population of the Putumayo landrace were used as replications. Paraquat was sprayed at 50 day intervals, while the preemergence herbicides were sprayed at 90 day intervals. Harvest started at 18 months after planting out, 17 months after treatment initiation. The polypropylene mat yielded the highest percent harvest (80%), followed by Oxyfluorfen (50%), paraquat (20%), oryzalin (12.5%). There were replication (genotype) effects that suggest varying tolerance to paraquat and oryzalin. Estimated palm heart yields (3731 plants/ha), corrected for % harvest, were highest with polypropylene mat (490 kg/ha), followed by oxyfluorfen 1.2 ai (425 kg/ha) and 0.6 ai (330 kg/ha). Paraquat severely inhibited growth of the suckers that assure future harvests. The performance rating of these weed control treatments was: mat = oxyfluorfen > oryzalin > paraquat.

POTENTIAL OF FISH CULTURE WASTE WATER AS AN IRRIGATION AND NUTRIENT SOURCE FOR BELL PEPPERS IN THE VIRGIN ISLANDS

M.C. Palada*, W. Cole, S.M.A. Crossman, J.E. Rakocy and J.A. Kowalski, University of the Virgin Islands Agricultural Experiment Station, RR2, Box 10000, Kingshill, VI 00850.

Using fish culture waste water may benefit vegetable production by reducing the need for high quality irrigation water. Fish waste water also contains nutrients, reducing the need for chemical fertilizers. A study was conducted to integrate fish (tilapia) culture with field production of bell pepper (*Capsicum annuum* L.). Waste water from low and high fish stocking densities and variable water exchange rates were applied to bell peppers 2 to 3 times weekly. These treatments were compared with fish sludge, cow manure and commercial N fertilizer. Fish waste water and sludge were applied by hand in the first year. A modified irrigation system was used in the second year. All other treatments were drip irrigated. In 1992 marketable yield was highest (9.0 t/ha) in plots with N fertilizer (drip fertigation) followed by plots applied with sludge (5.0 c/ha). Lowest yield (2.0 t/ha) was obtained from plots applied with fish waste water. In 1993 plots applied with fish waste water had a slightly higher yield (7.0 t/ha) than N-fertigated plots. Marketable yield was highest (10.4 t/ha) in plots treated with sludge.

CULTURAL METHODS AFFECTING BELL PEPPER PRODUCTION IN SOUTHEASTERN OKLAHOMA.

Vincent M. Russo, United States Department of Agriculture, Agricultural Research Service, South Central Agricultural Research Laboratory, POB 159, Lane, OK 74555.

Bell pepper yields can be improved if appropriate cultural methods are used. Cultural methods evaluated at the South Central Agricultural Research Laboratory are reviewed. Yields were best from plants grown on soil with deep 'A' horizon and soil pH approaching neutral. Fertilizer applied at 1.2 or 1.5 fold the recommended rate did not improve yield. Planting by mid-May was superior to later plantings. Delaying harvest up to 2 weeks after the first fruit reached US #1 grade improved marketable yield up to 1.8 fold over plants whose harvest was not delayed. This was because crown fruit increased in size and branch fruit attained marketable size. Knowledge of the cultural methods best suited for pepper in a geographical area should aid in increasing marketable yield.

ROWCOVER AND BLACK PLASTIC MULCH EFFECTS ON TOMATO PRODUCTIONS

Ibrahim G. Rubeiz* and Marlene M. Freiwat, American University of Beirut, FAFS, Beirut, Lebanon.

Tomato cv. Alwadi were grown under floating rowcover, black plastic mulch, mulch plus rowcover, or no protection i.e. control, for studying the effect on yield in terms of earliness, total yield and average fruit size. Early yield was significantly increased by the mulch treatment while the rowcover treatment yielded the least ($P < 0.05$). Total

PRECOCIOUS RESPONSE OF PEJIBAYE TO LEGUME, GRASS AND BLACK POLYPROPYLENE GROUNDCOVERS DURING ESTABLISHMENT IN HAWAII.

DeFrank and Charles R. Clement Dept. Horticulture University of Hawaii. 3190 Maile Way. Honolulu. HI 96822.

Pejibaye (*Bactris gasipaes*, Palmae) is being evaluated for palm heart production in Hawaii. Counts of parasitic nematodes and yields at 18 months and weed control were evaluated in response to: *Arachis pintoi*, *Cassia rotundifolia* cv. Wynn, *Desmodium ovalifolium*, *Chloris gayana*, and woven black polypropylene mat. Four open-pollinated progenies from the Benjamin Constant population of the Putumayo landrace were used as replications. Twenty five percent of the plants were harvested, with means of 5, 20, 15, 15, and 70%, respectively. Individual heart weights did not vary significantly among treatments (mean = 169 g). Actual yields were significantly different, with means of 31, 125, 92, 99, and 440 kg/ha, respectively. All vegetative ground covers competed with pejibaye for nutrients, which explains the harvest percentages and yields. *D. ovalifolium* and *C. gayana* provided acceptable weed control. *A. pintoi* provided good ground cover, but reduced weed control.

RELATIVE GREENNESS READINGS OF DRY BEAN CULTIVARS

Dale T. Lindgren*, Dermot Coyne, David Nuland, Ralph B. Clark, and Dan Schaaf, Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724

Color (chlorosis) of eight dry bean cultivars was measured using a Chlorophyll Meter at 5 sites over 2 years in western Nebraska to determine color differences due to cultivars, site, year and iron treatments. There were significance differences between cultivars for color at all sites. However, cultivars were not consistent in color response to iron treatments across all sites. 'Spinel' and 'Othello' were classified as having darker green foliage while 'Steuben Yellow Eye' and 'Redcloud' were classified as having lighter green foliage. Correlations between foliage color and yield were greater on sites with higher pH. Selections can be made for bean lines which consistently have darker green foliage color. However, they are not always the highest yielding lines.

THE EFFECTS OF SOIL TYPE, SULFUR FERTILITY, AND HARVEST DATE ON THE PUNGENCY OF TG1015Y ONIONS

B. K. Hamilton*, L. M. Pike., Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133.

A field study was conducted on TG1015Y onions (*Allium cepa* L.) grown in the Lower Rio Grande Valley of Texas. Treatments included two soil types (clay & loam), four harvest dates throughout the bulbing process, and two S rates [0 kg S/ha (standard) & 22.4 kg S/ha (high)]. Laboratory analysis included pyruvic acid concentration for pungency measurement, percent dry matter, and sucrose, glucose, and fructose concentrations. Harvest date influenced all variables tested. Percent dry matter generally decreased as bulbs matured (8.0 to 6.9% DM) with a slight increase at maturity (7.4% DM). Enzymatically developed pyruvic acid concentrations ranged from 3.13 to 4.03 $\mu\text{mole/g}$ fresh wt. There was an upward trend of pyruvic acid over the bulbing process. Total sugars, measured by HPLC methods, tended to increase during bulb development (39.3 to 46.5 mg/g fresh wt.). However, sucrose decreased during the last two harvests causing a corresponding increase in glucose and fructose. The S treatment had no effect on any of the factors measured. The only influence by soil type was sugar concentration, with the loam field being higher in glucose.

AIR SUPPLY FOR LETTUCE TIPBURN PREVENTION AND ITS EFFECTS ON TRANSPIRATION AND PHOTOSYNTHESIS.

Jan M. Kossowski*, Darlene A. Wilcox, and Robert Langhans, Cornell University, Plant Science Bldg., Ithaca, NY 14850-5908. First two authors: Department of Fruit and Vegetable Science. Last author: Department of Floriculture and Ornamental Horticulture.

Tipburn is considered a major limiting factor to lettuce production in greenhouses and controlled environment agriculture facilities. Conditions which promote optimal growth also result in high levels of tipburn incidence. It has been reported that air flow directed at inner leaves of rapidly growing lettuce can prevent tipburn without a concurrent reduction of growth, assumedly due to increased transpiration with increased air movement over leaf surfaces.

Lettuce was grown in the greenhouse in nutrient film technique, with additional lighting providing total of 17 to 19 $\text{mol m}^{-2} \text{d}^{-1}$ of PAR. Control plants developed tipburn 20 to 25 days after seeding. Plants with air supplied to inner leaves by a perforated plastic sleeve did not develop tipburn up to 35 days after seeding. Diurnal changes in physiological parameters were measured starting one

week prior to harvest. Leaves of control plants had significantly higher stomatal conductance and transpiration than did those of air-supplied plants, although diurnal patterns of control and air-treated plants were similar. Air flow treatment had no significant effect on the rate of photosynthesis. However, air-supplied plants had a slightly lower percentage of dry matter than control plants. The apparent growth reduction resulting from the air flow treatment evidently reduced the demand for calcium.

SUMMER LETTUCE PRODUCTION POTENTIALS FOR HIGHER ELEVATIONS

Gregory Welbaum and Charlie O'Dell*, Extension Horticulturist, Commercial Vegetable Production, Dept. of Horticulture, VA Tech, Blacksburg, VA 24061-0327

Greenhouse grown transplants of 23 lettuce varieties were produced in 1" diameter speedling flats, seeded May 1, transplanted to the field in early June when plants were 4 weeks of age. Transplants were grown in a commercial potting media of peat-vermiculite-perlite. Loose leaf, butterhead, crisphead or iceberg and cos types were included, field-planted at the Elam Swarey farm in Burkes Garden, Tazewell County, Virginia, at an elevation of 3,400 ft. above sea level. No crisphead (iceberg) varieties were found to be satisfactory in yield or quality for area conditions. Of loose leaf varieties, 'New Red Fire' and 'Red sails' were judged highly adapted for high elevation summer production at sites above 2,000' elevation and/or for fall production at lower Piedmont and coastal areas for October and November harvests. 'Tiara', a dark green loose leaf was judged the best of its type in this test. Of the cos types, 'Pyramid' and 'Ideas' were best adapted to high elevation summer production or lower elevations fall production. Of the butterhead types, 'Condor' and 'Encore' were suited to higher elevations, 'Condor' showing more heat tolerance.

OPTIMIZING TOMATO YIELDS IN HIGH TUNNELS

Otho S. Wells,* Department of Plant Biology, University of New Hampshire. Durham, NH 03824

Tomato production in high tunnels is very intensive, although relatively low-input. However, optimal use of every square foot of growing space is critical to maximizing returns. Utilizing the basket-weave trellis system, 'Ultrasweet' tomatoes were grown in 4 (replicated), 14-foot-wide high tunnels in 4 rows per tunnel at 3.5 ft between rows. In-row spacing of 12, 18, and 24 inches was combined with removal of sideshoots below the first flower cluster: one or three shoots at 18 and 24-inch spacing and none or one at 12-inch spacing. The highest marketable yield per plant was 22 lbs at 24 inches and three sideshoots, while the lowest yield per plant was 13.9 lbs at 12 inches and no sideshoots. The highest yield per sq ft was 4.2 lbs at 12 inches and no sideshoots, while the lowest yield per sq ft was 2.5 lbs at 24 inches and one sideshoot. The yield response to spacing and side-shoot removal was inverse for lbs per plant and lbs per sq ft. There was no difference in fruit size among any of the treatments. In a comparable experiment under field conditions, the highest yield per plant was 12.6 lbs at 24 inches and one sideshoot; and the highest yield per sq ft was 2 lbs at 12 inches and one sideshoot. The percentage of marketable fruit in the tunnels and in the field was 93.0 and 85.1, respectively.

EFFECT OF THE APPLICATION OF SPROUTING PROMOTERS ON TWO POTATO CULTIVARS (*Solanum tuberosum* L.)

Ibis Quintero, Maritza Ojeda, Yolanda Pérez, Judith Zambrano and Juan Mazano*

Posgrado de Horticultura, Escuela de Agronomía, UCLA, Barquisimeto, Venezuela.

In tubers 'Kennebec' and 'Russet' were applied acetylene, carbide and ethylene to promote sprouting, subsequently the tubers were stored at temperatures of 10 and 15 C. The experiment was a completely randomized, factorial design. The evaluations were done weekly. 'Kennebec' sprouted from the second week of applied the treatments to 10 and 15 C while 'Russet' sprouted only to 15 C. In the fourth evaluations the effect of promoters was not significantly different to the control. 'Kennebec' at 10 C showed greater percentage of sprouting and number of sprout/tuber with respect to 'Russet', but at 15 C were not detecte significant differences between the cultivars for these parameters. Number of sprout/tuber in 'Kennebec' was not affected by the promoters but 'Russet' treated with acetylene and carbide at 10 C showed the largest number of sprout/tuber. The greater sprout length was presented by 'Kennebec' in both temperatures.

EFFECT OF METHANOL ON BIOMASS ACCUMULATION AND PHOTOSYNTHETIC EFFICIENCY OF VEGETABLE CROPS IN HAWAII
Hector R. Valenzuela,* Osamu Kawabata and Harry Yamamoto, Dept. of Horticulture, 3190 Maile Way, University of Hawaii at Manoa, Honolulu, HI 96822

Methanol sprays reportedly increased yields of several crops in Arizona by 50 to 100 percent (Nonomura and Benson PNAS 89:9794(1992). Reports from other parts of the country have shown conflicting results with regards to the effect of methanol sprays on yields of horticultural crops. Several greenhouse and growth chamber (controlled temperature, day length, and photosynthetic photon flux) experiments were conducted to evaluate the effect of methanol sprays on the growth and productivity of several vegetable crops in Hawaii. Treatment spray solutions consisted of 20-25% methanol, 0.5% low biuret urea, 0.001% chelated iron, and 0.02% surfactant. Control sprays only contained urea, chelated iron, and surfactant. Each experiment consisted of at least 5 weekly methanol sprays. Flowering cabbage, *Brassica campestris* var. *parachinensis*, had greater biomass production when sprayed with methanol in the late summer months. Similar results were obtained with choy sum in a 2 by 2 factorial experiment with methanol and water stress treatments. However, choy sum did not respond to methanol treatments in follow-up greenhouse trials, perhaps attributable to the shorter and Overcast days experienced in the fall and winter. Okra, chili pepper, and eggplant showed no response to methanol sprays. Okra showed a trend toward increase yields in response to methanol sprays, but differences were not significant. Follow-up studies in the greenhouse and in the field, which include evaluation of photosynthetic efficiency through chlorophyll fluorescence determinations will be presented.

VEGETABLE PRODUCTION IN NORTH DAKOTA

Marcus B. Jackson*, Shanjianq Ke, Barbara A. Laschkewitsch, and Chiwon W. Lee Department of Crop and Weed Sciences, North Dakota State University: Fargo, ND 58105

The growing conditions of North Dakota are characterized by short frost-free seasons (< 120 days), long photoperiods, a large fluctuation in summer temperatures, and fertile soils especially in the Red River Valley region. Commercial production of vegetables in the state has been increasing with renewed interests in fresh and processed products. Currently, about 1,200 acres are devoted to vegetable production in the state with most of it concentrated in the eastern part of the state. This excludes 158,000 acres used for potato production. The top ten vegetables, excluding potato, are onion, carrot, sweet corn, squash, cabbage, red beet, muskmelon, asparagus, pumpkin, and garlic in the descending order of acreages devoted. While onions are grown mainly for fresh markets, carrots are produced for both fresh and dehydrated products. Acreages for these two crops are expected to expand, especially for supplying onions for ringing operations and carrots for dehydration and p-carotene extraction. Each year, selected cultivars of onions, carrots and other vegetables are evaluated for their performance in this northern growing environment.

SOIL MOISTURE REQUIREMENTS FOR OPTIMAL GROWTH OF VEGETABLE AMARANTH

Bharat P. Singh* and Wayne F. Whitehead, Fort Valley State College, Fort Valley, GA 31030-3298

In literature, amaranth is described as a stress tolerant crop. However, most of the investigations have been concerned with the production of grain crop. The soil moisture regime which promotes maximum vegetative growth is yet to be established. During 1993, the vegetative growth response of amaranth to different soil moisture levels was determined in a greenhouse study. Amaranth cultivar Hin Choy was grown in Dothan sandy loam soil at four soil moisture levels of 6.0, 9.0, 12.0 and 14.0 % (w/w) in a randomized complete block experiment with ten replications. Plant height, leaf number, leaf area, leaf fresh and dry weight, stem fresh and dry weight, root fresh and dry weight, leaf-stem ratio, and stem fresh and dry weight were recorded. All parameters gained significantly with each increment in the soil moisture level up to 12%. There was no difference in plant response between 12% and 14% soil moisture. The study indicated that for optimum vegetative growth, amaranth requires a moisture stress free soil environment.

STUDIES ON SEEDLING PRODUCTION OF ASPARAGUS UNDER DIFFERENT GROWTH CONDITIONS

*Okasha, Kh. A. & Gomma H.

Strawberry Improvement Center, Faculty of Agric.
Ain Shams Univ. Cairo, Egypt. FAX 5721628

This study was carried out on Asparagus (*Asparagus officinalis* L.) during the two successive seasons of 1987/1988 and 1988/1989 at the Agricultural Experimental Station of National Research Center at Shalakan Kaloubia Governorate. The investigation was aimed to study the effect of cultivar, propagation methods and polyethylene mulching on plant growth and performance.

The application of plastic mulching caused significant increases in plant height, number of shoots, number of branches, fern fresh and dry weight and roots an rhizome fresh and dry weight.

Covering the soil surface with black and transparent polyethylene enhanced the vegetable growth of asparagus plant significantly, as compared with unmulched treatments. Mulching with transparent polyethylene increased soil temperature over black polyethylene mulch and both treatments were higher in soil temperature than the control. Concerning the variation existed among cultivars, UC 157 F₁ showed a significant increment in vegetable growth compared with UC 157 F₂.

6.0 POSTER SESSION 8 (Abstr. 552-565) Fruits/Berries/Woody Ornamentals: Stress

DORMANCY DEVELOPMENT AND STRESS TOLERANCE IN 'BRAEBURN' AND 'FUJI' APPLE NURSERY STOCK

Steven P. Castagnoli*, Leslie H. Fuchigami, Tony H. H. Chen, Liping Zhen
Department of Horticulture, Oregon State University, Corvallis, OR 97331

Studies were performed on the development of dormancy, cold hardiness, and desiccation tolerance, and the effect of manual defoliation timing on performance of 'Fuji' and 'Braeburn' apple nursery stock. Dormancy development, response to defoliation, and desiccation tolerance of apple differed from those reported for other temperate woody plant species. Dormancy development in 'Fuji' was approximately two weeks ahead of 'Braeburn', and was strongly regulated by temperature. Photoperiod had no influence on dormancy development of 'Fuji'. Desiccation tolerance of both varieties was greatest just prior to the onset of dormancy and early dormancy. This pattern in the seasonal development of tolerance to desiccation is not typical of temperate woody plant species. Early defoliation was detrimental to performance of 'Braeburn', but had little effect on 'Fuji'. Early defoliation promoted earlier spring budbreak in 'Fuji'. Development of freezing tolerance in both apple varieties was typical of other woody plants, and coincided with the onset of dormancy. Maximum hardiness was achieved after the requirements for dormancy were completely satisfied.

COLD RESISTANCE OF 'ANJOU', 'BARTLETT' AND 'BOSC' PEAR TREES.

Delmer O. Ketchie* and R. Kammereck, Washington State University, Tree Fruit Research and Extension Center Wenatchee WA 98801.

Samples of current season shoots of Anjou, Bartlett and Bosc pears were collected throughout the year during 1990, '91 and '92. Differential thermal analysis (DTA) and vital staining with triphenyltetrazolium chloride (TTC) were used at the sampling times to determine freeze resistance. Freezing tests were conducted on greenhouse-grown trees. Temperatures to freeze the trees were predetermined by DTA. After freezing TTC staining, acid fuchsin test and growth were used to determine survival. All three varieties began to acclimate after terminal growth ceased in late June until October. Bartlett and Anjou obtained about -25°C resistance by this time and Bosc about -23°C. After frost began, Anjou and Bartlett gained an additional resistance to -33°C and Bosc to -28°C. Trees frozen artificially at -27°C had limited growth but did leaf out only to die a month later. Trees frozen at -33°C never leafed out. Bartlett trees at -27°C looked better than Anjou and Bosc trees but died also.

PHOTORESPIRATION OF LEMON TREES IN RESPONSE TO TEMPERATURE AND ATMOSPHERIC CO₂ CONCENTRATION

Chris A. Martin* and Richard L. Garcia, Department of Botany, Arizona State University, Tempe, AZ 85287-1601

Eureka lemon (*Citrus limon* L. 'Eureka') trees were grown in factorial combinations of low (L) or high (H) temperature [day/night temperature regimens of 29.4C/21.1C or 40.5C/32.2C] and ambient (C₃₈₀) or enriched (C₆₈₀) atmospheric CO₂ concentrations [380 umol mol⁻¹ or 680 umol mol⁻¹, respectively]. After growth under these conditions for 5 months, morning and afternoon leaf carbon assimilation measurements were made with a temperature-controlled cuvette attached to a portable photosynthesis system. Net (P_n) and gross (P_g) photosynthesis were measured at 30 umol mol⁻¹ intervals as leaves were exposed to cuvette CO₂ drawdowns from 700 to 300 umol mol⁻¹ at 21% and 1% O₂, respectively. Photorespiration (R_p) was estimated as the difference between P_n and P_g. Generally, R_p increased as cuvette CO₂ decreased. Morning and afternoon R_p of leaves adapted to LC₃₈₀ conditions were similar. Morning R_p was higher than afternoon R_p for leaves adapted to LC₆₈₀ conditions. Morning R_p was higher for leaves adapted to HC₃₈₀ conditions as compared to HC₆₈₀-adapted leaves. In contrast, afternoon R_p was higher for leaves adapted to HC₆₈₀ conditions than for H&-adapted leaves.

GROWTH AND ION CONTENT OF INTERGENERIC BC₁ CITRUS X PONCIRUS PROGENY IN RESPONSE TO A 9-MONTH SALINIZATION PERIOD

Ilhami Tozlu*, Charles L. Guy, Quinvin Cai, and Gloria A. Moore, Horticultural Sciences and Environmental Horticulture Departments, IFAS, University of Florida, Gainesville, FL 32611

There is wide variation in *Citrus* and related genera in tolerance to cold and salt stress. While *Poncirus trifoliata* (L.) Raf. is an important rootstock for cold regions, it is salt sensitive. *C. grandis* (L.) Osb., on the other hand, is cold sensitive, but is relatively salt hardy. We are attempting to map genes (quantitative trait loci, QTLs) influencing salt and cold tolerance in *Citrus*, using a BC₁ population from [*C. grandis* x (*C. grandis* x *P. trifoliata*)]. As a first step, 2 year old containerized replicates of individual BC₁ progeny plants have been salinized with 30 mM NaCl over a 9 month period under greenhouse conditions. Growth response under saline conditions, as evaluated by plant height and node number, varied significantly between individual progeny. Concentrations of 11 macro- and micro-elements, including Na and Cl, in leaf and root tissues were also determined. Ultimately, this data will be analyzed in conjunction with our current linkage map of this population, which consists of more than 200 marker genes, in order to map QTLs for salt tolerance.

EFFECTS OF SUBLETHAL HEAT STRESS ON ENDODORMANCY AND ECODORMANCY OF PEACH AND HYBRID POPLAR

Michael Wisniewski*, Jörg Sauter², Valerie Stepien², and Les Fuchigami¹,

¹USDA-ARS, Kearneysville, WV, ²Christian Albrecht Universität, Kiel, Germany, ³Horticulture Dep't., OSU, Corvallis, Oregon.

Sublethal heat stress has been shown to decrease or eliminate deep supercooling of flower buds in woody plants and to release plants from endodormancy. Experiments were conducted to characterize the effect of heat stress on endodormancy and ecdormancy in peach (cv Loring) and two hybrid poplars. Protein synthesis (*de novo*) and patterns of protein expression were also monitored. In order to determine optimum treatment temperatures, shoots, collected September-March, were exposed to a range of temperatures (35-60 C) under wet or dry conditions for 1-6 h. Shoots were then placed in the greenhouse and cumulative budbreak was monitored over 4 weeks. Samples of bud and bark tissues were collected during and up to 72 h after heat treatment for SDS-PAGE analysis. Data indicate: 1) twigs must be immersed in water for the heat treatments to be effective; 2) heat treatments resulted in a release from endodormancy and a decrease in thermal units needed for budbreak during ecdormancy; 3) 40 C for 2-4 h was optimum in fall and late winter whereas 45 C was the optimum temperature to induce budbreak in midwinter; 4) optimum temperature for peach floral buds (37.5 C/2h) was lower than for vegetative buds (40 C/4h), and 5) heat treatments also decreased cold hardiness. Protein synthesis decreased significantly following heat treatment but was significantly greater than controls (room temp) 24-48 h after heat treatment.

EFFICACIES OF CRYOPROTECTANTS APPLIED TO STRAWBERRY PLANTS INOCULATED WITH ICE-NUCLEATION-ACTIVE BACTERIA

Michele R. Warmund and James T. English, Department of Horticulture, University of Missouri, 1-87 Agriculture Building, Columbia, MO 65211

Cryoprotectants were applied at labeled rates to primary flowers of 'Honeoye' strawberry (*Fragaria x ananassa* Duch.) plants at full bloom to determine their effects on the floral organs. Frostgard at 50 ml/liter or KDL at 22 ml/liter injured pistils and resulted in misshapened fruit. Floral buds that were closed when cryoprotectants were applied were uninjured. In other experiments, efficacies of cryoprotectants were determined after floral tissues of 'Honeoye' strawberry plants were inoculated or not inoculated with the ice-nucleation-active (INA) bacteria, *Pseudomonas syringae* van Hall and subjected to sub-freezing temperatures. None of the products protected primary or secondary flowers against freezing injury regardless of the occurrence of INA bacteria. INA bacteria were not recovered from primary flowers of treated plants that were killed by low temperature exposure, indicating that non-bacterial nuclei may incite freezing in these tissues.

SALINITY AND LEAF GAS-EXCHANGE OF ANNONA SOUAMOSA

Thomas E. Marler* and Yasmina Zozor², College of Agriculture & Life Sciences, University of Guam, UOG Station, Mangilao, Guam 96923; ²Fairchild Tropical Garden, 11935 Old Cutler Rd., Miami, FL 33156

Leaf gas-exchange responses of *A. souamosa* seedlings to salinity were studied in sand culture in a series of glasshouse experiments. Trees were irrigated with a complete nutrient solution as the control, or with this solution amended to 3 or 6 dS/m with sea salt. Inhibition of net CO₂ assimilation, stomatal conductance of CO₂, and transpiration was apparent 14 days after treatments were imposed, and continued to decline until day 30 to 35. The diurnal pattern of leaf gas exchange was not altered by salinity. Salinity reduced CO₂, light energy, and water use efficiencies. Dark respiration and internal partial pressure of CO₂ were unaffected by salinity stress. Results indicated that substrate salinity inhibited photosynthesis of *A. souamosa* via limitations on mesophyll capacity for CO₂ assimilation and had little effect on gas phase limitations.

A COFFEE YIELD MODEL FOR KONA, HAWAII

D. Richard Loero, Kent D. Kobayashi*, and H.C. Bittenbender, Department of Horticulture, University of Hawaii at Manoa, Honolulu, HI 96822 U.S.A.

Coffee (*Coffea arabica* L.) is grown mainly as an unigated crop in the Kona district of Hawaii (Big Island). Previous research has shown that water status and crop load are major components of annual yield fluctuations exhibited by coffee in Kona. The need for a quantitative method to estimate yield has led to the development of a yield model. Seven years of historical yield, meteorological, and soil data were utilized. Meteorological and soil data were used in a soil water balance model developed with the simulation language Stella® (High Performance Systems Inc.) to generate a daily soil water status value. Then, values for the number of days and mm of deficit (duration and magnitude) were grouped in trimesters and used to estimate yield:

$$Y_n = 17425 - 6.3(T2)_{n-1} - 181(T3)_{n-1} + 0.26(Y_{n-1})$$

where Y_n is the current year's yield (kg/ha); T2 is the water deficit during April-June of the previous year (days-mm); T3 is the water deficit during July-September of the previous year (days-mm); Y_{n-1} is the previous year's yield (kg/ha); and n is the current year. The use of this model permitted yield estimation three months before anthesis and nine months before the start of harvest with a mean prediction error of 17% or 3,154 kg/ha of coffee cherry.

EFFECTS OF HYDROGEN CYANAMIDE AND CYSTEINE ON BREAKING DORMANCY AND PHYTOTOXICITY

Liping Zhen and Leslie H. Fuchigami, Department of Horticulture, Oregon State University, Corvallis, OR 97331

Hydrogen cyanamide (CY) induced earlier, more uniform, and a higher percentage of budbreak in poplar (*Populus alba* x *P. grandidentata*, N C 5339). CY was phytotoxic at 0.5 M or higher concentration. Percent budbreak increased and percent dieback decreased when plants were treated with a mixture of CY and Cys. No

difference was found in percent budbreak or dieback between plants treated with CY alone and a mixture of CY and Ser. Mixing CY with Cys concentrations *in vitro* reduced the percentage of the cyano group, and mixing of Cys with CY concentrations decreased the percentage of the SH group remaining in the mixture. Mixing CY with Ser concentrations *in vitro* had no effect on CY level. These studies suggest that the SH group reacts with CY directly and the improvement of budbreak and toxicity caused by mixing CY and Cys may be due to the reduction of CY concentration.

561 PB 406

THE EFFECTS OF COLD TEMPERATURES ON THE SURVIVABILITY AND POST-STRESS PERFORMANCE OF CONTAINER-GROWN NURSERY STOCK

Jennifer L. Dwyer*, N. Curtis Peterson and G. Stanley Howell, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

The nursery industry continues to develop improved methods for successfully overwintering container-grown nursery stock. Experiments were conducted using several different species of woody ornamentals ranging from species known to be cold hardy to cold tender. Eighteen species were subjected to temperatures ranging from 20F to -20F and observed for post-stress performance and viability. Rates and timing of acclimation, mid-winter hardiness, and deacclimation of seven species were determined by examining the shoots for injury after subjecting them to controlled freezer conditions. The roots of the same seven species were exposed to three different overwintering systems: in a polyhouse, pot-to-pot above the ground, and pot-in-pot below the ground. Cold hardiness of root and shoot systems and the effects of warming temperatures on shoots were determined as well as the post-stress performance of each species. Results of this research will be presented.

562 PB 409

THE EFFECT OF PHOTOPERIOD ON THE COLD HARDINESS AND CARBOHYDRATE CONTENT OF TWO CULTIVARS OF SOUTHERN MAGNOLIA

C.L. Haynes*, M.A. Dirr and R. Severson, Department of Horticulture, University of Georgia, Athens, GA 30602-7273

The cold hardiness of *Magnolia grandiflora* 'Claudia Wannamaker' and 'Little Gem' was determined under 8, 12 and 16 hour daylengths. Temperature was maintained at 25C day and 20C night. In addition, specific and total carbohydrates of both cultivars were analyzed. Cold hardiness and carbohydrate content were tested at the beginning (0 week), middle (5 week), and end (9 week) of the study. As expected, both southern magnolia cultivars were more cold hardy after 9 weeks at 8 hour daylengths with -9C cold hardiness estimates, as compared to 12 and 16 hour daylengths. The 12 and 16 hour daylengths resulted in similar cold hardiness estimates of -6C after 9 weeks. Additional cold hardiness and carbohydrate information will be presented.

563 PB 412

RICHARDS FUNCTION IN FREEZING TOLERANCE DETERMINATION WITH ELECTROLYTE AND PHENOLIC LEAKAGE TECHNIQUES

Tomasz Anisko, Cynthia L. Haynes, and Orville M. Lindstrom*, Dept. of Horticulture, University of Georgia, Georgia Station, GA 30223-1797

Freeze tests were performed on stem sections of *Fraxinus americana*, *Lagerstroemia indica*, *Magnolia grandiflora*, *Rhododendron* 'Red Ruffle', *Zelkova serrata*, and leaves of *Magnolia grandiflora* and *Rhododendron* 'Red Ruffle' in the tinter and summer of 1993. Freeze injury was quantified using electrolyte and phenolic leakage techniques and compared to the lethal temperature range determined by visual method assisted by differential thermal analysis. Richards function was fitted to the electrolyte and phenolic leakage data by the modified Gauss-Newton method. The inflection point of the Richards function coincided with the lethal injury range for non-acclimated leaves, but overestimated the freeze tolerance for

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acclimated leaves and for both acclimated and non-acclimated stems. A proposed interception point of the lower asymptote and a line tangential to the curve inflection point provided an improved estimate of the lethal injury range in most of the species.

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PB 415

A COMPARISON OF COLD HARDINESS AMONG *LAGERSTROEMIA INDICA* X *FAURIEI* CULTIVARS GROWN IN ZONES 7 AND 8 USING DIFFERENTIAL THERMAL ANALYSIS.

April D. Edwards*, Steven E. Newman, and Frank B. Matta, Department of Plant and Soil Sciences, Box 9555, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS 39762.

Adolph J. Laiche, South Mississippi Branch Experiment Station, P.O. Box 193, Poplarville, MS 39470.

During recent freezes in the mid-south, crape myrtles have suffered severe freeze damage. Some increased levels of cold hardiness have been observed in the National Arboretum crape myrtle releases, but the degree of tolerance has not been documented. The relative cold hardiness of five hybrid crape myrtle cultivars 'Muskogee', 'Natchez', 'Osage', 'Tuskegee' and 'Yuma' was determined using differential thermal analysis. Stem samples were collected from established trees at two locations, Poplarville, Zone 8 and Starkville, Zone 7 once per month from October through April. Freezing point suppression was determined from five samples from each cultivar and location. Observed exotherms ranged from -7C to -13C.

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POST-TEMPERATURE EFFECTS ON HEAT OF METABOLISM AFTER "NEAR-LETHAL" HEAT STRESS IN STEM TISSUES OF RED-OSIER DOGWOOD

A.M. Shirazi*, Y.M. Moreno, L.H. Fuchigami and L.S. Daley, Department of Horticulture, Oregon State University, ALS 4017, Corvallis, OR 97331-7304

Previously, we reported recovery of plants from "Near-Lethal" (NL) (Sub-Lethal) stresses was dependent on stage of development and post-stress environment. Dormant plants exposed to NL-heat, freezing, and hydrogen cyanamide either died or were severely injured when stored at 0°C or recovered at 23°C and natural condition. This study reports on the changes in the evolution of metabolic heat in dormant red-osier dogwood (*Cornus sericea* L.) stem tissues after heat stress. Heat stress (51°C for half an hour) was followed by one of two post-stress environment (PSE) (0° or 23°C dark condition). Isothermal measurements of the heat of metabolism of the tissues were taken after 0, 1, 2, 5, 7 and 11 days of PSE. A significant reduction of metabolic heat generation occurred in heat stressed plants at 0°C PSE from one to 11 days of incubation as compared to the non-stressed tissues. At 23°C PSE, no significant differences of heat generation between stressed and non stressed tissues were found within 7 days of incubation. The rate of metabolic heat measured by decreasing temperature scanning microcalorimetry (21° to 1°C) were lower in heat stressed tissues. Arrhenius plots of metabolic heat rate gave a linear slope for non-stressed tissues and a complex slope for NL-stressed tissues at lower temperatures. Energy of activation (Ea) between 1°-8°C were 15.45 and 83.882 KJ mol⁻¹ for NL-heat and non-stressed tissues, respectively.

67 POSTER SESSION 9 (Abstr. 566-589) Propagation/Cell & Tissue Culture: Turf/woody Plants

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PB 003

HEAT EFFECTS ON ROOTING SOFTWOOD CUTTINGS OF 'AUTUMN FLAME' AND 'INDIAN SUMMER' RED MAPLE

Hongyi Zhang* and William R. Graves, Department of Horticulture, Iowa State University, Ames, IA 50011-1100

Alden M. Townsend U.S. National Arboretum, 3501 New York Avenue NE, Washington, DC 20002

Single-node cuttings of 'Autumn Flame' and 'Indian Summer' red maple (*Acer rubrum* L. and *A. x freemanii* E. Murray) were placed in subirrigated perlite that was kept at 29, 33, or 36 C at the cut ends for 3 weeks. Number and mass of roots and pigment quality and transpiration of leaves were greater for 'Autumn Flame' than 'Indian Summer' and decreased with increasing temperature for both cultivars. Rooting percentage at 29, 33, and 36 C was 75, 75, and 25 for 'Autumn Flame' and 13, 13, and 0 for 'Indian Summer'. Earlier

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work has shown > 90% of cuttings of both cultivars root at $\approx 22\text{ }^{\circ}\text{C}$, and plants of 'Autumn Flame' are more heat resistant than those of 'Indian Summer'. Results of this experiment suggest the effect of heat on rooting of cuttings might be used to predict genotypic differences in heat resistance of whole plants.

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PB 006

AUXIN SENSITIVITY OF DOUGLAS-FIR STEM CUTTINGS

William M. Proebsting, Department of Horticulture, Oregon State University, Corvallis, OR 97331

Douglas-fir clones have a wide range of rooting potential, but the species is generally considered difficult to root. We have reported previously that NAA is approximately 14-times more active than IBA in the clones tested, with an optimum of about 5 to 10 mM NAA. In contrast, other programs routinely use about 25 mM IBA to propagate Douglas-fir cuttings, a concentration that is relatively inactive in our clones. To address questions raised by these observations, we have incorporated auxin treatments into our long term program to select Douglas-fir clones with high rooting potential. We collect 20 cuttings of each clone identified in Christmas tree plantations, and retain clones rooting $\geq 80\%$. Beginning in 1991, we treated 10 cuttings of each clone with 5 mM NAA, the other 10 cuttings with 25 mM IBA. Over three years, 1158 clones received the split treatments. Of 222 clones rooting $\geq 80\%$ approximately half rooted $\geq 80\%$ in response to NAA only. The remainder either responded to IBA or to both NAA and IBA. These results support our previous observations that NAA stimulates rooting of Douglas-fir better than IBA. However, they also suggest that there may be clones sensitive to IBA or to both NAA and IBA.

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PB 009

IMPROVING PROPAGATION AND PRODUCTION TECHNIQUES FOR NATIVE PLANTS

John M. Englert* and Gwen C. Meyer, USDA-SCS-National Plant Materials Center, Bldg. 509, BARC-East, Beltsville, MD 20705.

In recent years the use of native plant materials for conservation and revegetation projects has received increased awareness and interest. The National Plant Materials Center (NPMC), in cooperation with the USDI-National Park Service, is involved in the revegetation of disturbed areas within our National Parks using native herbaceous and woody plants. This involves the collection of germplasm from selected niches within the Parks, an increase in seed and production of transplants, and reestablishment of native communities in natural areas.

One major focus of the program is to develop technology for improving native plant propagation and production, which should make the use of native plants more viable in the commercial sector. Germination of species of *Tridens*, *Dichanthelium*, *Danthonia*, *Helianthus*, *Schizachyrium*, and *Andropogon* has been improved to 80-95% by altering the germination environment. Production of these species in plugs has also been streamlined to maximize space efficiency and provide cost-effective methods for planting native grasses and wildflowers.

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PB 012

A MODIFIED FORCING SOLUTION SYSTEM PROMOTES PROPAGATION OF WOODY SPECIES

Guochen Yang* & Paul E. Read, Department of Horticulture. University of Nebraska, Lincoln, NE 68583-0724

A forcing solution containing 200 mg 8-hydroxyquinoline citrate per liter and 2% sucrose has enhanced availability of cutting materials by forcing dormant woody stems in the off-season. Auxins, such as IBA, included in the forcing solution promoted subsequent rooting by increasing root number per cutting and root length for privet. Inclusion of IBA in the forcing solution following the initial use of GA₃ in the forcing solution counteracted the undesirable effects of GA₃ on rooting and stimulated rooting after taking advantage of the favorable effects of GA₃ on bud break and shoot elongation. However, the ability of IBA to counteract the negative effects of GA₃ on rooting was dependent on the length of GA₃ treatment. The modification of forcing solution system by sequentially including GA₃ and then replacing GA₃ with IBA expedited propagation of privet. Production of candidate cuttings or explants was stimulated by including GA₃ in the forcing solution, and rooting of the cuttings was promoted by subsequent auxin or cytokinin inclusions in the forcing solution to replace GA₃. This modified forcing solution system also proved to be a successful and efficient model for propagation of other difficult to propagate woody species.

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PB 015

SUBIRRIGATION PERMITS ROOTING OF SOFTWOOD CUTTINGS OF RED MAPLE WITHOUT MIST OR FOG

Hongyi Zhang* and William R. Graves, Department of Horticulture, Iowa State University, Ames, IA 50011-1100

A rapid, easy, and economical way to root softwood cuttings of red maple (*Acer rubrum* L. and *A. x freemanii* E. Murray) has been developed. Single-node cuttings were treated with 8 g IBA/kg and inserted in flats of perlite. Flats were placed in larger trays without drainage holes. Cuttings were subirrigated by adding a complete solution with 100 mg N/L to trays, saturating perlite at the bottom of the flat, below the cuttings. After 3 weeks, 94, 98, 100, and 100% of cuttings of 'Indian Summer', 'Autumn Flame', 'Red Sunset', and 'Autumn Blaze' had rooted, respectively. Leaves on cuttings remained turgid without mist or fog. In a subsequent study of 'Red Sunset', 0, 50, and 100 mg N/L in the subirrigation solution resulted in 37, 100, and 100% rooting with 8 g IBA/kg and 0, 43, and 67% rooting without IBA. Rooting was fastest and chlorophyll in leaves was highest with both IBA and nutrients. Subirrigation can replace mist or fog when rooting cuttings of red maple.

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EVALUATION AND PROPAGATION OF SUPERIOR CADDO MAPLES

John C. Pair, KSU Horticulture Research Center, 1901 East 95th South, Wichita, KS 67233

In 1983, a trial was initiated to compare numerous selections of sugar maple (*Acer saccharum*) for adaptability to stressful conditions in south central Kansas (zone 6). Included were seedlings of Caddo maple, a southern ecotype, collected from a population native to central Oklahoma. Selected trees have shown superior resistance to scorch and leaf tatter compared to cultivars in the trade. Pre-dawn measurements indicated higher xylem water potential than 'Green Mountain' and 'Fairview' under drought stress. Leaf emergence of Caddo maples has been earlier in the spring, and fall color develops later than other sugar maples. Propagation of potential cultivars with early fall color has been principally by T-budding on Caddo understock in July and August, although side-veneer grafting in winter has been successful. In addition to superior summer leaf quality, growth in caliper and total height has been greater than other *A. saccharum* cultivars.

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PB 041

SEED COAT STRUCTURE RELATED TO GERMINATION IN EASTERN REDBUD (CERCIS CANADENSIS L.)

Rodney O. Jones and Robert L. Geneve*, Department of Horticulture, University of Kentucky, Lexington KY 40546

Seed coat anatomy in the hilar region was examined in dry, imbibed and germinating seeds of Eastern redbud. A discontinuous area was observed between macrosclereid cells in the palisade layer of the seed coat which formed a hilar slit. A symmetrical cap was formed during germination as the seed coat separated along the hilar slit and was hinged by the macrosclereids in the area of the seed coat opposite to the hilar slit. The discontinuity observed in the palisade layer was the remnant of the area traversed by the vascular trace between the funiculus and the seed coat of the developing ovule. There were no apparent anatomical differences in the hilar region of the seed coat between dormant and non-dormant imbibed seeds. However, the thickened layer of mesophyll cells of the seed coat in this region and the capacity of the endosperm to stretch along with the elongating radicle may contribute to maintaining dormancy in redbud seeds.

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PB 044

SEED PROPAGATION OF SOUTHERN SEAOATS IN PEAT-BASED SOILLESS MEDIA

Gary R. Bachman* and Ted Whitwell, Department of Horticulture, Clemson University, Clemson, SC 29634-0375

Southern seaoats (*Uniola particulata*) are difficult to propagate from seed due to low seed numbers produced and cold dormancy effects. To efficiently produce southern seaoats in the nursery industry the dormancy must be effectively broken to assure quick and even germination. 24 hr soaks in gibberilic acid (100 and 500 ppm) or scarification of the seed coat combined with GA soaks were compared. Seeds were planted in 50/50

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peat/perlite medium 2.5 cm deep. 21 DAT both the 100 and 500 ppm GA soaks had higher germination rates. The 100 ppm GA was determined to be most effective (56% germination) with the seedlings being 3 cm in length. The 500 ppm treated seeds were 6 cm in length but twisted from the GA causing excessive cell elongation.

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PB 056

PLANT REGENERATION FROM CULTURED SOMATIC TISSUES OF HAZELNUT

Xiaoline Yu*¹ and Barbara M. Reed², ¹Dept. of Horticulture, Oregon State University, Corvallis, OR 97331; ²USDA/ARS National Clonal Germplasm Repository, 33447 Peoria Road, Corvallis, OR 97333-2521

Adventitious shoots were regenerated from stem segments or leaf discs of hazelnut (*Corylus* species) in vitro shoot cultures. Five to 10% of stem segments of 'Nonpareil' regenerated adventitious shoots on modified MS medium and NCR-COR medium supplemented with 200 mg·l⁻¹ glutamine and combination of 1 or 5 µM thidiazuron (TDZ) and 0.1 µM naphthaleneacetic acid (NAA). Callus derived from stem segments of 'Nonpareil', 'Tonda Gentile Romana', and 'Willamette' and leaf discs of 'Dundee' cultured on medium with TDZ and NAA also produced shoots (buds) after transfer to NCR-COR medium or modified MS medium with benzyladenine (BA) and indole-3-butyric acid (IBA). Adventitious roots were produced from leaf discs and stem segments on medium with NAA alone or with high levels of IBA or NAA combined with low levels of BA. Regenerated shoots of 'Nonpareil' and 'Willamette' were multiplied, rooted, and acclimatized in the greenhouse. This provides a starting point for improving the plant regeneration frequency to a level useful for genetic manipulation.

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PB 047

STABILITY OF A VARIANT LEAF TYPE OF 'THORNLESS EVERGREEN' BLACKBERRY FOLLOWING A REGENERATION CYCLE IN VITRO

Margaret A. Norton* and Robert M. Skirvin, University of Illinois, Department of Horticulture, Urbana, IL 61801

Rubus laciniatus Willd. 'Thornless Evergreen' (TE) is a chimeral blackberry with a thornless epidermis that overlies a genetically thorny interior. Most canes of TE produce leaves with 5 finely cut (lacinate) leaflets. Occasionally, canes appear which produce leaves with entire leaflets. Genetically pure thornless plants were regenerated from epidermal cells of chimeral TE with lacinate leaves. These regenerants exhibited somaclonal variation for growth habit, degree of thornlessness, and fruitfulness. All had lacinate leaves. When moved to the field, some of these regenerants produced canes with entire leaflets.

To examine the stability of the entire leaflet characteristic, plants were regenerated from lacinate leaves and entire leaves of both dwarf and normal pure thornless TE regenerants. Regenerants were rooted, moved to soil, and grown in the greenhouse for observation. Stability of this characteristic will be discussed.

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PB 050

EFFICIENT PLANT REGENERATION FROM LEAF AND PETIOLE EXPLANTS IN RED RASPBERRY

Cynthia Coher*, H. Mathews, V. Dewey and R. Bestwick

Agrirope Inc, 8505 SW Creekside Place, Beaverton, OR 97005

Raspberry has very cultivar specific requirements for proliferation. Plant regeneration rates from isolated explants are inconsistent and vary widely among cultivars. As a step towards developing a viable transgenic system in red raspberry (*Rubus idaeus* L.) we first developed an efficient and consistent protocol for plant regeneration from isolated explants. A modified MS medium with cytokinin BA gave vigorous shoots with an average proliferation rate of 3-5 depending on the cultivar. These vigorous shoot proliferants served as an ideal explant source for plant regeneration experiments. The average rate of shoot regeneration from leaf explants was 72, 32, 68, and 72% for cvs. Canby, Chilliwack, Meeker and Heritage respectively. In addition to leaf, petiole explants were equally good sources for inducing shoot organogenesis. In all the above-mentioned cultivars, 44-57% of the petiole explants gave rise to healthy and vigorous shoot regenerants in culture. The regenerated shoots were induced to root on a rooting medium and were successfully transplanted to the greenhouse. This regeneration system was successfully applied in our laboratory for developing gene transfer system in red raspberry (see abstract by Mathews, et al).

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PB 053

METHODS TO MAXIMIZE AND MINIMIZE SEGREGATION OF CHIMERAL PEAR (PYRUS SPP) IN VITRO

Abdelrahman S. Al-Wasel* and Robert M. Skirvin University of Illinois, Department of Horticulture, Urbana, IL 61801

Variegated 'Louise Bonne' (LB) pear is a periclinal chimera in which the LIII layer is albino. Chimeral shoots propagated in vitro segregate spontaneously into green, albino, pale, or rearranged chimeral types, making them difficult to maintain in culture. We investigated the role of growth regulators on chimeral stability and destability to find a combination that would maintain the chimera through repeated subcultures. 70 to 90% of shoots remained chimeral on Lepoivre (LP) medium supplemented with 8 µM BA or less. Only 36 to 58% of shoots grown at concentrations greater than 8 µM were stable. Shoots grown on LP with thidiazuron (TDZ) were very unstable (4 to 44%). NAA had no significant effect on chimeral stability. While shoots multiplied better on LP, the chimeral pattern was more obvious on MS, making it a good screening medium. Selection and subculturing chimeral shoots on a good medium (LP with 2 to 4 µM BA) increased the percentage of chimeral shoots from 26% at the 4th subculture to 84% at the 27th subculture.

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PB 059

IN VITRO ROOTING OF PYRUS GERMPLASM

Barbara M. Reed*, USDA/ARS National Clonal Germplasm Repository, 33447 Peoria Road, Corvallis, OR 97333-2521

Cultures of 49 *Pyrus* species and cultivars and one *Pyronia* (*Pyrus x Cydonia* hybrid) selection were screened in vitro to determine a rooting method suitable for a wide range of germplasm. Auxin treatment was required for rooting in most cases. Eighteen of the 50 accessions rooted with a 15 sec. 10 mM indole-3-butyric acid (IBA) dip followed by growth on medium with no growth regulators (NCR). Medium with 10 µM IBA for one week followed by NCR medium produced 12 rooted accessions, but NCR medium alone produced little or no rooting. A 15 sec. dip in 10 mM naphthaleneacetic acid (NAA) followed by NCR medium was tested on 29 accessions which rooted poorly on the other three treatments. Twice as many (28%) rooted on NAA as on either IBA treatment (14% each). Additional treatments combining IBA with darkness or higher temperature were also tested and were successful for some cultivars. *P. calleryana*, *P. koehnei*, *P. pashia*, *P. hondoensis*, *P. ussuriensis*, *P. betulifolia*, *P. regelii*, *P. pyrifolia* hybrid cv. Shinseiki and the *Pyronia* selection failed to root. Twenty two of the 32 *P. communis* cultivars rooted on at least one treatment.

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PB 082

FACTORS AFFECTING REGENERATION AND ROOTING OF APRICOT SHOOTS DERIVED FROM IMMATURE EMBRYOS

Joseph C. Goffreda* and Anita Scopel Department of Plant Science, Cook College, Rutgers University, New Brunswick NJ, 08903-0231

Immature embryos or cotyledons were cultured at three stages of development (PF=3, 30-60, or 100) from two unrelated apricot genotypes. Explants were cultured on MS medium supplemented with 2,4-D (0 or 1 µM) and either BA or TDZ (0, 0.5, 5.0 or 20 µM). Stage 1 embryos cultured on MS media without hormones tended to form embryoid-like structures. Regeneration was highest with stage 2 cotyledons on media containing between 5-20 µM TDZ and 1.0 µM 2,4-D; shoot morphology was abnormal at the highest level of TDZ.

In another factorial experiment, stage 2 cotyledons were cultured on media containing TDZ (six levels, 0 to 20 µM) in combination with either 2,4-D (0 or 1 µM) or IBA (0, 1, or 5 µM). Regeneration of normal shoots was highest on the medium containing 5 µM IBA and no TDZ. Regenerated shoots were transferred to woody plant medium (WP) containing 3% sucrose and supplemented with 6 µM 2iP and 2.2 µM BA to promote stem elongation. Shoots were transferred to WP media supplemented with NAA or IBA to induce rooting. Culture on media containing 10 µM IBA in total darkness induced rooting in less than two weeks.

STIMULATION OF EMBRYOGENESIS BY ANTIBIOTICS FROM AMERICAN ELM COTYLEDONS.

Nian-Qing Shi* and Zong-Ming Cheng Department of Crop and Weed Sciences, North Dakota State University, Fargo, ND 58105

Some antibiotics mimic plant hormones on cell growth and plant regeneration. Cefotaxime and carbenicillin were tested in American elm for induction of embryogenesis from cotyledonary explants, which normally show organogenesis. Cotyledons from 1-week-old in vitro germinated seedlings were placed on a shoot regeneration medium (a modified MS medium containing 15 μ M BA, B5 vitamins and 0.3% gelrite) with various levels of cefotaxime and carbenicillin. One hundred percent of explants showed embryogenesis in the medium supplemented with 125 μ g/ml cefotaxime; 75% explants regenerated somatic embryos in medium with 500 μ g/mg carbenicillin; and only 50% explants produced somatic embryos in the medium with both of these antibiotics. In control medium without antibiotics, 100% explants regenerated shoots, instead of somatic embryos. Further studies are necessary to determine the nature of these antibiotics on shifting developmental pathways and their stimulatory effect on embryogenesis from American elm cotyledons.

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PB 088

Shoot Proliferation and plant Formation from Neem

(*Azadirachta indica* Juss.) with Thidiazuron

Yasseen Mohamed-Yasseen, Department of Horticulture, University of Illinois, IL, 61801

Neem is considered to be one of the most promising plants for producing pesticides, pharmaceutical, as well as many commonplace materials. A protocol for shoot formation from nodal and stem explants is described. Stem nodes and stem segments were obtained from mature tree and cultured in Murashige and Skoog medium (MS) supplemented with 0.5 μ M thidiazuron (TDZ), and 0.5 μ M naphthaleneacetic acid (NAA). Stem node explants produced multiple shoots which were separated and cultured on MS supplemented with 0.01, 0.03, 0.5, or 0.9 μ M TDZ with 0.5 μ M NAA. Stem explants produced callus which regenerated shoots upon transfer to a fresh medium. Formed shoots produced roots in proliferation medium or rooted in MS supplemented with 3.3 μ M indolebutyric acid, and were transferred to soil. Number of produced shoots increased with increasing TDZ concentration but shoot and root length decreased.

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PB 091

PLANT REGENERATION FROM EMBRYOGENIC CALLUS TISSUES OF KENTUCKY BLUEGRASS

Shanqiang Ke* and Chiwon W. Lee, Department of Crop and Weed Sciences, North Dakota State University, Fargo, ND 58105

Coleoptile tissues from dark-germinated seedlings of Kentucky bluegrass (*Poa pratensis* L.) cv. Touchdown were excised and cultured on MS medium supplemented with 1.5-2.5 mg/liter picloram plus 0.2 mg/liter benzyladenine (BA) or with 4 mg/liter 2,4-D. Embryogenic calli were formed on media containing 1.5 mg/liter picloram plus 2.5 mg/liter 2,4-D in the dark. When these embryogenic calli were subcultured on MS medium containing either 0.15-0.3 mg/liter picloram or 0.2-0.5 mg/liter 2,4-D in a 16-h day/8-h night photoperiod, 10.5% of the cultures regenerated shoots. Pretreatment of cultures in the dark for 2 weeks prior to light exposure slightly increased the plant regeneration efficiency to 15.5%. Pigmentation of the regenerants varied with a ratio of 8.5 completely green: 2.5 green plus albino: 1 completely albino plants. The shoots were multiplied in the medium containing 0.5 mg/liter BA plus either 0.2 mg/liter picloram or 0.1 mg/liter indoleacetic acid (IAA). Over 90% cultures in the shoot proliferation medium produced roots after 4 weeks.

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PB 094

CALLUS INDUCTION AND SHOOT ORGANOGENESIS IN *RHODODENDRON* 'BESSE HOWELLS' AND 'CATAWBIENSE ALBUM' Yiqin Ruan* and Mark Brand, Department of Plant Science, U-67, University of Connecticut, Storm, CT 06269

Combinations of the auxins 2,4-dichlorophenoxyacetic acid (2,4-D), indolebutyric acid (IBA), and naphthaleneacetic acid (NAA), with isopentenyladenine (2-iP) were studied in Woody Plant (WP) medium for callus induction and shoot organogenesis from leaves of *Rhododendron* 'Besse HORTSCIENCE, VOL. 29(5), MAY 1994

Howells' (BH) and 'Catawbiense Album' (CA). IBA was more effective than NAA and 2,4-D at inducing shoot organogenesis when combined with 2-iP. Addition of 1 μ M IBA and 15 or 30 μ M 2-iP to WP medium resulted in the highest percentage of explants producing shoots (90% in BH, 100% in CA), and the greatest number of shoots per explant (18.4 in CA, 10.1 in BH) after 12 weeks of culture. Shoot organogenesis also occurred using 1 μ M NAA and 2-iP combinations, but the number of shoots produced was much less than for IBA treatments. 2,4-D and NAA were more productive than IBA for callus induction. Media containing 1-10 μ M 2,4-D plus 5 μ M 2-iP, or 10 μ M NAA plus 15 μ M 2-iP, were the best for callus production. In studies using thidiazuron instead of 2-iP as the cytokinin, leafy buds and very short shoots developed.

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PB 097

MICROPROPAGATION AND REGENERATION OF AN ELITE ASIAN WHITE BIRCH SELECTION

Jeffrey P. Schnurr* and Zongming Cheng, Crop and Weed Sciences Dep't., North Dakota State Univ., Fargo, ND 58105

A selection of *Betula platyphylla*, from an open pollinated population, was made for upright growth habit, cold hardiness, and a dark green canopy. A micropropagation system was developed to overcome the difficulty with conventional propagation techniques. Shoot-tip cultures were best established in 3/4 strength MS medium supplemented with 0.1 μ M thidiazuron. After 5 weeks in culture, shoots were transferred to woody plant medium (WPM) with 4.4 μ M BA. The highest proliferation rate occurred at 24 C on WPM, solidified with agar, and supplemented with 2.2 μ M BA. Shoots rooted in vitro and ex vitro and have been established in the field. A regeneration system has also been developed using leaves from aseptic cultures. The optimum conditions for shoot regeneration include a 2-week dark treatment before exposure to a 16-h day/8-h night cycle. Large, healthy leaf explants cultured on WPM with 20 μ M BA regenerated shoots at the highest frequency. Regenerated shoots, when transferred to the micropropagation system, proliferate successfully. Currently, a transformation system for this selection is being developed.

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PB 100

IMPROVED REGENERATION FREQUENCY OF KENTUCKY BLUEGRASS FROM CALLUS CULTURES

Jeffrey D. Griffin* and Margaret S. Dibble, Dept. of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow ID 83844-2339

Genetic transformation of Kentucky bluegrass (*Poa pratensis* L.) requires methods for high-frequency regeneration of plantlets from cultured cells. Regeneration of this important turf species has been reported, albeit at a low frequency from seed-derived callus. We tested the potential of 3 synthetic auxins, used in the callus initiation and growth medium, for their ability to promote regeneration in 3 bluegrass varieties. 10 μ M 2,4-D promoted regeneration from 0 to 5% of calli, 30 μ M and 60 μ M picloram promoted regeneration from 0 to 8% of calli, and 10 to 60 μ M dicamba, in combination with BA, promoted regeneration from 1% to 8% of calli. In a subsequent experiment, both 60 μ M and 90 μ M dicamba, with 20 μ M BA, promoted regeneration from 45% of calli averaged across varieties. These media were tested for the promotion of regeneration in 12 diverse bluegrass varieties. Although up to 45% of the calli from some varieties regenerated plantlets, the response of other varieties was markedly lower, indicating a genetic component in the response to these media.

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AXILLARY SHOOT REGENERATION IN CHINKAPIN OAK

Sudeep Vyapari* and Houchang Khatamian, Department of Horticulture, Forestry and Recreation Resources, Kansas State University, Manhattan, KS 66506-4002

Surface disinfested nodal and shoot-tip sections of chinkapin oak (*Quercus muehlenbergii* Engelm.), obtained from adult or juvenile source, when cultured on WFM supplemented with BA or kinetin (1.0 -5.0 mg l⁻¹) produced greater number of axillary shoots per explant and shoot lengths than MS medium. Nodal and shoot-tip explants cultured in WFM containing cytokinins, BA or kinetin (0.1 - 5.0 mg l⁻¹) resulted in greater number of axillary shoots than media containing auxins, 2,4-D or NAA (1.0 - 5.0 mg l⁻¹). In vitro grown shoot explants cultured in WFM shoot multiplication medium containing thidiazuron did not produce axillary shoots. Microshoots when cultured in WFM plus NAA or IBA (0.1 -2.0 mg l⁻¹), or subjected to IBA (0.5 mg l⁻¹) pulse treatment (0, 5, 10 or 15 min.) did not root.

MICROPROPAGATION OF SPIGELIA MARILANDICA (L.) S.L. Kitto, Dept. Plant and Soil Sciences, University of Delaware, Newark, DE 19717.

Spigelia marilandica, an herbaceous perennial native to the temperate eastern United States, has great potential for the sunny garden due to a fairly long flowering period and long (3.5-5.5 cm) tubular corollas that are scarlet on the outside and yellowish within. Non-wild collected seeds were disinfested using conventional procedures, and after 8 wk at 4°C, four seeds germinated in vitro. Preliminary experiments examined seedling lines (# 1, 2, 5 and 6) and media (MS versus DKW.) Line 6 was found to be consistently more proliferative over a six month period. Trend analysis demonstrated no difference in total number of axillary shoots produced on full versus 1/2 MS media. MS-derived microcuttings were chlorotic but appeared to root better than DKW-derived microcuttings.

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IN VITRO MULTIPLICATION OF STEWARTIA MALACODENDRON L., AN ENDANGERED WOODY SPECIES

Murdock Ray Gillis* and Michael E. Kane, Environmental Horticulture Department, University of Florida, Gainesville, FL 32611-0670

Stewartia malacodendron L. (silky camellia), a small deciduous tree bearing showy flowers, has potential as a landscape plant. Propagation problems, limited availability and consequent high unit cost have slowed its acceptance as a landscape plant. Given its potential value as a landscape plant, studies were initiated to define a micropropagation protocol. Surface sterilized shoot tips and nodal explants from two-year-old container grown seedlings were established on Woody Plant Medium supplemented with 4.44 µM benzyladenine (BA) and solidified with 0.8% TC[®] Agar. Sustained growth of subcultured shoot tips and nodal segments required the addition of 8 -15 µM gibberellic acid (GA₃) to the medium. Regenerated shoots were 3 - 5 cm long, unbranched and typically consisted of three subdivisions. Effects of cytokinin type (BA, 2iP or kinetin) and concentration (0 - 25 µM) with factorial combinations of GA₃ (0 - 30 µM) on shoot multiplication, elongation and diameter were determined after a 28 day culture period. Moderate GA₃ levels (10 & 20 µM) in combination with 2.5 µM BA yielded the highest quality microcuttings.

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PS 132

TISSUE PROLIFERATION IN ELEPIDOTE RHODODENDRONS

Richard K. Kiyomoto* and Mark H. Brand, Connecticut Agricultural Experiment Station, New Haven, CT 06504-1106 and Department of Plant Science, University of Connecticut, Storrs, CT 06269.

Experiments were conducted on tissue proliferation (TP) development and in vitro and ex vitro growth of tissues from plants with (TP+) and without TP (TP-). In 1993 the increase in TP in one-, two-, and three-yr-old 'Holden' and 'Besse Howells' was 3%, 52%, and 32% and 10%, 26% and 21%, respectively. No differential mortality was observed. Shoot tip cultures initiated from TP+ and TP- 'Montego' showed 10-12 mo were required for miniaturization and multiplication in TP- shoot tips and 4 mo in TP+ shoot tips. TP- cultures require 10 uM 2-iP for normal shoot proliferation; whereas TP+ cultures had to be transferred to hormone-free medium after 6 mo to maintain normal shoot morphology. Cutting propagation from TP- and TP+ plants older than 5 yr, showed persistence of morphological aberrations associated with TP+ plants.

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LOW-TEMPERATURE STRESSED-INDUCED FLOWERING OF THE 'WASHINGTON' NAVEL ORANGE (*CITRUS SINENSIS* L. OSBECK) WAS INCREASED BY APPLICATION OF PUTRESCINE OR SPERMIDINE TO THE FOLIAGE

Anwar G. Ali and Carol J. Lovatt, Department of Botany and Plant Sciences, University of California, Riverside, CA 92521.

The ability of arginine (50 mM), putrescine (10 and 20 mM), and spermidine (10 and 20 mM) to enhance low temperature stressed-induced flowering of 5-year-old container-grown 'Washington' navel orange trees was evaluated. The metabolites were applied to the foliage at the end of the 4-week low-temperature treatment of 8-h days at 10°C and 16-h nights at 7°C; the trees were then moved to warmer conditions.

All treatments had a positive effect on floral intensity. Putrescine (20 mM) and spermidine (10 mM) significantly increased ($P = 0.05$) total flower number and both the number and proportion of leafless inflorescences per tree. However, the number of floral shoots per tree, as well as the number of leafy inflorescences and number of vegetative shoots were not significantly influenced by the metabolites.

The results suggest that polyamines are important to the development of flowers, but not leaves, along the axis of the inflorescence.

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PB 161

CITRUS MANAGEMENT SURVEYS

J. J. Ferguson*, Horticultural Sciences Department and C.L. Taylor, Program Evaluation and Organizational Development, University of Florida, Gainesville, FL 32611

Management problems and information needs of Florida's approximately 12,000 citrus growers on 791,290 acres were identified by a statewide citrus management survey. During the summer of 1992, citrus county agents' mailing lists were compiled to create a master list of 2,964 addresses, from which a sample of 833 growers was selected by a stratified proportional sampling procedure. Three hundred ninety-eight useable questionnaires were returned from commercial citrus grove owners and managers in 23 citrus producing counties, representing 307,022 acres, 39% of the current acreage. Survey data on general management, young tree care, pest management, water management and cold protection was further analyzed by whether respondents' groves were bedded or unbedded. Information from this citrus survey and previous ones has been used to develop and evaluate comprehensive statewide citrus extension programs.

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PB 164

POST-TRANSPLANT ROOT GROWTH OF CITRUS PLANTS AS INFLUENCED BY PRODUCTION TIME IN NURSERY CONTAINERS

Thomas E. Marler, College of Agriculture & Life Sciences, University of Guam, UOG Station, Mangilao, Guam 96923

An aeroponics system was used to determine root growth of *Citrus aurantifolia* Swingle following removal from containers. Rooted cuttings were planted in 0.46-liter containers in a 1 sand: 1 perlite medium, and watered daily and fertilized with a complete nutrient solution weekly. The plants were grown in the containers until root growth had filled the container volume. A sample of plants was removed from the bench after 86, 146, or 210 days in container production. Plants were bare-rooted and the existing root system dyed with methylene blue, and placed in the aeroponics system. The plants were maintained in the aeroponics system for 50 days, then were harvested and the roots separated into pre-existing roots and new roots. Two dimensional area and dry weight of roots were measured. Relative new root growth of plants that were maintained 210 days in the containers was less than that of plants that were removed from containers earlier. The data indicate that maintaining plants in containers for extended periods of time may reduce root regeneration following removal from containers.

EFFECTS OF REDUCED RATES OF NITROGEN ON GROWTH AND MINERAL NUTRITION OF YOUNG 'PINEAPPLE' ORANGE TREES

A.K. Alva* and D.P.H. Tucker, Univ. of Fla., IFAS, Citrus Res. & Edu. Ctr., 700 Expt. Sta. Rd., Lake Alfred, FL 33850

Recent trends in increased nitrate contamination of groundwater in parts of Central Florida have prompted this study to evaluate the potential for reducing the rates of nitrate (N) fertilizer to citrus. 'Pineapple' orange trees on Swingle citrumelo rootstock growing on Candler fine sand were selected for the study. Fertilizer blends were applied using N as: (1) soluble ammonium nitrate and calcium nitrate in 4 applications per year and (2) controlled-release sources (Meister, Osmocote, Escote in one application per year and IBDU and Neutalene in 2 applications per year). Nitrogen rates varied 18-154, 36-308, and 57-454 g/tree/year during the first, second and third year after planting, respectively. Tree growth and leaf mineral concentrations (during the first 3 years) and fruit size and juice quality (second and third years) were not adversely affected by application of reduced N rates. Fruit yield (third year) was lower in the trees which received ≤ 114 g N/tree/year than in those which received higher rates of N.

MANGIFERA PAJANG - PROSPECT FOR COMMERCIAL PRODUCTION AND MANGO IMPROVEMENT

Serudin Tinggal* and Thean S. Tee, Universiti Brunei Darussalam, Gadong 3186, Brunei

Magifera panjang Kostermans, indigenous to Brunei is widely adapted to lowland and hilly areas. The vigorous tree grows tall (30 - 40 metres high). Grafting on *M. indica* stock or own stock has dwarfing effect and shortens juvenile stage to stimulate fruit production within 5-6 years. The obicular fruits are large with tough brown skin. The thick golden yellow flesh is juicy, pleasant to eat, having aromatic fragrance. Some cultivars are less fibrous. The fruit has wide traditional usage and demand is seemingly unsatisfiable.

Mangifera pajang is quite tolerant to various diseases affecting mangoes. Insect pests do not appear to damage the trunk or the fruits. The blossoms on stout and erect flowering spikes attract a host of pollinators. Anthracnose problem is unknown even in the wet season. These features are useful for possible transfer to the more susceptible *M. indica* cultivars.

'HASS' AVOCADO PHENOLOGY IN CALIFORNIA - PRELIMINARY RESULTS. P. W. Robinson*, M. V. Mickelbart, and M. L. Arpaia, Botany and Plant Sciences Dept., Univ. of CA Riverside, CA 92521.

Measurements of flowering, yield, vegetative and root growth were begun in Spring 1992 to establish a phenological model for 'Hass' avocado. Although rootstock (Thomas', Topa Topa', Duke 7' and 'D9') did not affect the timing or intensity of bloom, differences in yield were observed. Flowering occurred in March - April in both years, although the intensity of bloom in 1993 was drastically reduced due to an extremely heavy 1992-93 crop. Vegetative flushes occurred in April (following bloom) and July in both years. In 1993, however, cumulative growth was ca. 10-fold greater. Rootstock did not affect the timing or intensity of vegetative growth in either year. In both years, vegetative growth preceded root growth. In 1992, there were no differences detected in the timing or intensity of root growth related to rootstock. In 1993, however, the 'Topa Topa' rootstock produced more roots throughout the growing season. The timing and intensity of root growth during the spring flush were similar in both years. During Fall 1993, root growth rates, however, were consistently higher than those observed in 1992. Additionally, while root growth ceased in November 1992, roots have continued to grow through January 1994.

EXTENDING PRACTICAL INFORMATION TO CALIFORNIA CITRUS AND AVOCADO GROWERS

Guy Witney*, Gary Bender¹, Hodge Black², Ben Faber¹, Mark Freeman*, Rudy Neja¹, Neil O'Connell², and Nicholas Sakovich¹, University of California Cooperative Extension, ¹Southern Regional Office, U.C. Riverside Campus, Riverside, CA 92521 and ²South Central Regional Office, 9240 S. Riverbend Ave., Parlier, CA 93648

The county farm advisors in California are responsible to develop and distribute county newsletters to subtropical fruit farmers. The purpose of these newsletters is to appraise growers of emerging research developments and discuss topics of current importance. There is often repetition of information and duplication of mailing lists resulting in costly and inefficient use of the University's limited resources.

A cooperative effort between the California Avocado Society, the Citrus Research Board, and University of California farm advisors involved with subtropical fruit production has resulted in Subtropical Fruit News. This newsletter greatly improves Cooperative Extension's outreach education programs, makes better use of limited resources, yet retains the identity of each advisor and the county or region they serve. This newsletter should serve as a model for other extension programs looking toward maximizing efficiency.

CROP LOAD-RELATED DEFORMITY OF DEVELOPING *PISTACIA VERA* CV KERMAN NUTS

Louise Ferguson*, Patrick Niven, Andrea Fabbri, Lara Dallo, Walter Bentley, Paul Metheney and Vito Polito, Department of Pomology, University of California, Davis, CA 95616

A deformity designated as 'damage by other means' (DBOM) by California pistachio processors appeared in California's San Joaquin Valley orchards in 1990. Incidence, higher during the heavy crop year of this alternate bearing cultivar, was as high as 5% of harvested yield. This represents a significant loss as DBOM nuts cannot be used for shelling stock.

In 1993 ten weekly individual cluster samples from five heavily and five lightly cropped trees demonstrated a higher incidence of DBOM on heavily cropped trees. Further the damage occurred within one month of nut set, was exclusively on subterminal, adaxial positions of the rachis, and, often did not involve the nutmeat unless the deformity was extensive enough to expose the developing nutlet causing desiccation and abscission. Microanatomical studies demonstrated a deterioration of the parenchyma cells that form the inner cell layers of the endocarp (nut shell).

EFFECT OF UNICONAZOLE ON FLOWERING AND FRUIT SET OF MACADAMIA

Mike A. Nagao*, Elodie B. Ho-a and Judy Yoshimto, Department of Horticulture, University of Hawaii, Beaumont Research Center, 461 W. Lanikaula St., Hilo, HI 96720

Uniconazole at 0.20 g-ram of a.i./cm of trunk diameter was applied as a drench to potted 2 year-old *M. integrifolia* cv. Kau trees in July 1990, and reapplied in August 1991, August 1992 and August 1993. Observations between December 1991 to December 1993 showed that elongation of newly emerging vegetative flushes was inhibited within 6 months after the initial treatment. Shoots had a compact appearance, and the overall height of the trees was shorter than in untreated trees. By December 1993, diameters of the treated trees were also significantly smaller than the controls. Uniconazole increased the number of racemes, number of racemes with mature fruit set and fruit production in young trees during the 1992 and 1993 seasons. The effect was more pronounced in 1992 compared to 1993. Results from this study show that young macadamia trees can be brought into heavier bearing at an early age with uniconazole treatments.

THE INFLUENCE OF COASTAL BERMUDAGRASS AND CHEMICAL MOWING ON THE GROWTH, DEVELOPMENT, AND WATER UTILIZATION OF YOUNG PECAN TREES AS MEASURED IN NON-WEIGHING LYSIMETERS.

Josiah W. Worthington* Texas Agricultural Experiment Station, Rt. 2, Box 00, Stephenville, TX 76401

Budded, bare root, 'Wichita' pecan trees were planted and grown in inexpensive, 2m X.75m, non-weighing lysimeters for three growing seasons. Metered water was applied automatically through microirrigation systems as called for by switching tensiometers. Soil moisture tension was not allowed to exceed 25 Kpa. All tree/sod combinations received 336 kg N per hectare from 1-1-1 ratio commercial fertilizer.

Water use, tree growth, and nutrient status of trees grown under the following orchard floor management practices were measured:

1)Unmowed coastal bermudagrass, 2)Mechanically mowed bermudagrass, 3)Chemically mowed bermudagrass, and 4)Bare soil.

Water use by trees with chemical or mechanically mowed sod were intermediate in water use between unmowed and fallow soil treatments. In spite of the fact that water was never limiting for any treatment, fallow trees grew significantly larger than trees in any of the sodded treatments. A significantly lower level of foliar potassium was noted in trees growing in sod systems.

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PB 208

ROOT ADAPTATION TO COMPETITION.

D. M. Glenn* and W. V. Welker
USDA-ARS-Appalachian Fruit Res. Sta.
45 Wiltshire Road
Kearneysville, WV 25430

The effect of ground covers on water uptake was studied using peach trees grown in a 4-part split root system. In 1992, one section of the root system was in bare soil and 3 sections were in combination with 'K-31' tall fescue. In 1993, K-31 was eliminated in 2 additional sections, leaving 1 section in combination with 'K-31'. When grass transpiration was suppressed by covering the K-31, tree water uptake/cm of root length was greater in the presence of grass compared to bare soil under well watered conditions. These data indicate that peach trees compensate for interspecific competition by increasing root hydraulic conductivity.

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QUANTIFYING YIELD LIMITATIONS IN PEACH TREES

Ted M. DeJong, Pomology Department, University of California, Davis, CA 95616

Previous research using relative growth rate models indicates that under normal cropping conditions peach fruit growth and yield is alternately source and sink limited during different phases of fruit growth. An experiment was designed to test this concept on whole trees in the field. Shortly after bloom central leader trees of 'Spring Lady' and 'Cal Red' peaches, were thinned to various crop loads ranging from -50 to -400 fruit per tree. At specific intervals trees representing the full range of crop loads were harvested to determine mean individual fruit weight/total crop weight relationships for whole trees. Then, assuming that fruit on low cropped trees grew at their maximum potential growth rate (sink demand) and that total crop growth on unthinned trees represented the maximum dry matter available for fruit growth (source supply), the relative source and sink limitation between each harvest interval was calculated. With 'Cal Red', fruit growth appeared to be primarily source limited early and late in the season but primarily sink limited during the mid-period (Stage II) of fruit growth. At normal commercial crop loads, 'Spring Lady' was less source limited than 'Cal Red'.

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PB 214

GROWTH AND PRODUCTION OF ALMOND TREES AS AFFECTED BY PEACH AND PEACH-ALMOND HYBRID ROOTSTOCKS

Warren C. Micke*, Mark W. Freeman and James T. Yeager, Pomology Department, University of California, Davis, CA 95616

A replicated rootstock trial for almond was established in 1986 in the central San Joaquin Valley, a major almond growing area for this most widely planted tree crop in California. 'Nonpareil', the major cultivar in California, was used for this trial with 'Fritz' grown as the pollenizing cultivar. Two

standard rootstocks for almond, 'Nemaguard' and 'Lovell' peach, were compared to two newer peach-almond hybrid rootstocks, 'Bright's' and 'Hansen'. After eight years both hybrid rootstocks produced significantly larger trees than the peach rootstocks, based on trunk cross-sectional area. Trees on hybrid rootstocks frequently produced greater yields than those on peach rootstocks; although, differences were not always significant. However, there were generally no significant differences in production per trunk cross-sectional area (yield efficiency). Thus, increased production by trees on hybrid rootstock was the result of larger tree size and not an inherent increase in productive efficiency of the tree itself. Since trees on hybrid rootstock should be planted further apart than those on peach, production per hectare should not be significantly increased, at least under good growing conditions as represented in this trial.

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IMPROVEMENT OF APRICOT BUDBREAK BY APPLICATION HIDROGEN CYANAMIDE.

Raúl Leonel Grijalva Contreras*, and Fabian Rubles Contreras. INIFAP-CIRNO-CECAB. Apartado Postal 125, Caborca, Sonora, México. 83600.

A major obstacle to economic production of deciduous fruit tree under desert conditions is an insufficient period of chilling temperatures. Inadequate chilling on apricot may result in poor and uneven budbreak, reduced and delayed foliage development, sparse bloom, poor fruit set, and/or early grown cessation, with the objective of improve budbreak, applications of Hidrogen Cyanamide (H₂CN₂) were made to mature apricot 'Canino' trees on January 30. Two rates of H₂CN₂ and a control were evaluated for that proposal. Amount of chilling accumulated was 360 chill hours according Da Motta model. Hidrogen Cyanamide advanced budbreak 7 days at the highest rate as compared to control. Cumulative percent budbreak on March 15 were 40, 64 and 72% for o, 0.75 and 1.5% respectively. In this year, bud abscission was similar for all the treatments.

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PB 220

GROUND COVER MANAGEMENT SYSTEMS AND PREPLANT FERTILIZERS INFLUENCE PEACH TREE GROWTH, YIELD, MICRONUTRIENT AVAILABILITY AND UPTAKE.

John A. Ray*, Ian A. Merwin, and Warren C. Stiles, Dept. Fruit and Vegetable Science, 134 Plant Science, Cornell Univ., Ithaca, NY, 14853

Growth, nutrient uptake, and yield of peach (*Prunus persica*) trees was evaluated in various groundcover management systems (GMSs) for three years, with and without preplant soil additions of Zn, B, and Cu. In July 1990, micronutrients (none, or 135kg Zn-ha⁻¹+100kg Cu-ha⁻¹+1.1kg B-ha⁻¹) were incorporated into the upper 20 cm of a silty clay-loam soil (pH 6.7, 4% organic matter), and a fine-leaf fescue (*Festuca ovina*) turf was established. Trees were planted Apr. 1991, and four GMS treatments (wood-chip mulch, pre-emergence herbicide, post-emergence herbicide, and mowed turf) were superimposed upon the "+/-" micro-nutrient preplant treatments. Extractable Zn, Cu and B concentrations were greatly increased in soil of plots which had received preplant amendments. Peach leaf content of Zn, Cu and B was also greater in preplant fertilized plots in the year of planting. However, in subsequent years only leaf B (in 1992) and leaf Zn (in 1993) continued to respond positively to preplant soil treatments. No significant interactions were observed between GMS and micronutrient availability or uptake. Peach growth and yield were not affected by preplant treatments, but were substantially greater in mulch and pre-emergence herbicide plots compared with the mowed fescue turfgrass.

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PB 243

NEW BLOSSOM THINNERS FOR STONE FRUITS

Max W. Williams*, USDA, Agricultural Research Service, Tree Fruit Research Lab., 1104 N. Western Ave., Wenatchee, WA 98801.

Two chemicals being tested as blossom thinners for apple are effective for bloom thinning of peaches and nectarines. Monocarbamide dihydrogen sulfate (Wilthin) and Endothall applied at 90% of bloom open reduced fruit set by 50%. Fruit size and quality of the crop were improved. Both of the above chemicals gave adequate fruit removal without serious phytotoxic effects on leaves, buds or shoots. With chemical rates which over thinned, no fruit marking occurred on either nectarines or peaches.

Effect of planting density on root length distribution and mineral content in Y-shaped self rooted 'Flordaprince' peach trees.

T. Caruso¹, D. Giovannini², F.P. Marra¹ and A. Motisi¹ Istituto di Coltivazioni Arboree, Università di Palermo, 90128 - ¹Istituto Sperimentale per la Frutticoltura, sez. Forlì, Italy

Length and distribution of the roots of 2-year old cv. 'Flordaprince' peach trees grown under polyethylene greenhouse were studied over a two year period. The self-rooted, micropropagated trees were spaced 4.9 m between the row and 70, 52 and 42 cm. along the row to obtain a density of 3000, 4000 and 5000 trees/ha respectively. Orchard was clean cultivated, mulched along the row with black plastic fabric 1 m wide, and drip fertigated. Soon after harvest, for each density, the root system of one tree was totally excavated and root length, distribution, dry weight and nutrients content were determined. Total root length per tree was negatively related to planting density in two-year old trees (470, 380 and 320 m/tree respectively for 3000, 4000 and 5000 trees/ha). The shallowest root systems were found at 5000 trees/ha density and their length was unchanged from year to year. Root length density, ranging from 220 to 250 m/m), was only slightly affected by spacing in the two years. The roots were evenly distributed between the two sides of the rows.

THE EFFECT OF PRUNING ON FRUIT SET OF 'ANJOU' PEAR TREES.

Delmer O. Ketchie* and Eugene D. Fairchild, Washington State University, Tree Fruit Research and Extension Center, Wenatchee, WA 98801

Five different pruning techniques were begun in 1990 on Anjou pear trees to determine their effect on fruit set: (1) unpruned; (2) central leader, (3) central leader modified to Verner method; (4) stubbed into 2- to 4-year-old wood first year and then developed to central leader; and (5) mold-and-hold. Half of each treatment was spread, the other half not spread. Half of each of the combination training and spreading were tipped back to the first fruit bud at cluster bud time. The trees were 9 years old and on OHXF97 rootstock. The unpruned trees had the highest yield, 81 Kg/tree. The other treatments ranged between 52 and 58 Kg/tree. Regardless of pruning treatment, the spread trees out yielded the non-spread trees by 16 Kg/tree. There was essentially no difference between trees tipped in the spring and those that were not tipped.

DEFOLIATION OF TREE FRUIT NURSERY STOCK

Fenton E Larsen* and Stewart S. Higgins, Horticulture and Landscape Architecture, Washington State University, Pullman, WA 99164-6414.

Many tree fruit nurseries are limited to fall digging of deciduous nursery stock. Since trees may not defoliate naturally for timely digging, these nurseries may wish to defoliate chemically, which would be less expensive than hand-stripping and may more closely simulate natural leaf abscission. Consequently, test chemicals were applied with hand sprayers at commercial nurseries in central Washington State using single or double applications 1 wk apart. In 1992 on 7 apple cultivars and one pear, 500 ppm NPA + 150 ppm Ethrel significantly enhanced defoliation. Defoliation at 1000 ppm NPA was not superior to that at 500 ppm, and two applications were generally no better than one. However, in 1993, two applications were often more effective than one, and the addition of Ethrel to NPA generally enhanced defoliation if the combination of NPA + Ethrel was applied twice. Alanap and NPA were generally equally effective as defoliant. The addition of Ethrel to Alanap enhanced defoliation in only 3 of 9 cultivars, and then generally only when sprayed twice. Alanap + Ethrel was as effective with Alanap at 300 ppm as with Alanap at 500 ppm Ethrel by itself seldom increased defoliation.

ANATOMICAL CHARACTERIZATION OF ROOT MASS PROLIFERATION OF MARK ROOTSTOCK

A. Otero, R. Perry*, F. Ewers and R.T. Fernandez, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325.

A swelling of the rootstock shank, described as Root Mass Proliferation, has been frequently found in the field on apple trees of Mark rootstock. Swelling usually first appears on trees after they have been established for more than 3 years. The abnormal growth occurs above the soil line on the exposed rootstock shank and it extends to a depth of 10 - 15

cm below soil. Anatomical studies were conducted on maiden nursery trees and trees having been in the orchard for 3 to 6 years with light microscopy. In older trees, changes in normal tissue development occurred in the 2-4 cm outer zone of the swelling surface. Changing direction and proportion of xylem components gives an appearance of tracheary elements developing in a circular pattern. Abnormal xylem parenchyma seems to have its origin at the xylem parenchyma rays, which follow a straight plain of cell division. Clusters of lignified root initiation points are often found in the outer part of xylem, all around the rootstock shank. Removal of bark and phloem exposes hard nodules, which were found to consist of tracheary elements surrounded by lignified parenchyma cells all between xylem and phloem tissue encircling the rootstock shank. Abnormal development of xylem vessels suggests that there is an anatomical association between water transport and a reported physiological drought sensitivity of trees on this rootstock.

EVALUATION OF NEW APPLE CULTIVARS

Duane W. Greene* and Wesley R. Autio, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003-0910

There is a general increase in interest in planting new apple cultivars. Promising new apple cultivars have been identified from around the world and from breeding programs in Arkansas, British Columbia, New York, New Jersey and the PRI Program. Trees were propagated and planted in a cultivar evaluation block at the University of Massachusetts Horticultural Research Center. Fruit assessment consisted of laboratory analysis and visual and sensory evaluation. Fruit were rated and several cultivars were identified as showing extreme promise and being worthy of further evaluation. These apple cultivars include: Sansa, Ginger Gold, Honeycrisp, BC 8M 15-10, BC 17-30, Arlet (Swiss Gourmet), NY 75414-1, NY 429, Golden Supreme and SunCrisp (NJ 55). The strong and weak points of each cultivars will be discussed.

INFLUENCE OF EVAPORATIVE COOLING ON FRUIT DEVELOPMENT OF 'FUJI' APPLES (*MALUS PUMILA* MILL.)

Michael J. Perry*, Preston K. Andrews. and Robert G. Evans Washington State University, Department of Horticulture and Landscape Architecture, Pullman, WA 99164-6414

'Fuji' apples grown in the high light intensity of arid eastern Wash. are prone to sunscald damage. Evaporative cooling with over-tree sprinklers has become a commercially acceptable method for reducing the incidence of sunscald damage. A computer-controlled, over-tree evaporative cooling system was installed in a 3-yr-old commercial 'Fuji'/M.9 orchard near Walla Walla, Wash. Over-tree sprinklers (Nelson R10 Mini Rotators) applied 280 or 560 l·min⁻¹·ha⁻¹ (30 or 60 GPM/A) when core temperatures were ≥ 33C (91.4F). Fruit skin and core temperatures were monitored with thermocouples. Fruit growth was not different between treatments. Skin color was improved by cooling, but the incidence of sunscald was low in all treatments. Commercial pack-out was measured and culls were evaluated. Fruit quality was analyzed at harvest and after 14 weeks storage. Titratable acids and soluble solids were higher in the 560 l·min⁻¹·ha⁻¹ treatment at harvest.

EVALUATION OF MATURE 'BARTLETT' PEAR SELECTIONS GRAFTED ON FIVE ROOTSTOCKS

Wilbur Reil, David Ramos and Ronald Snyder, University of California. Cooperative Extension, 70 Cottonwood Street, Woodland, CA 95695

Three selections from different bud sources of Bartlett pear were planted in a split block experiment grafted to five rootstocks in 1971. In 1992 and 1993, significant yield and yield efficiency differences occurred between the three selections. The highest yielding selection produced 51 and 40% greater weight than the lowest. The lowest yielding selection also had smaller fruit and lower soluble solids.

Differences of 37 and 52% occurred between the highest and lowest yielding rootstocks. There were also significant differences in trunk cross sectional area, yield efficiency, fruit pressure and soluble solids between rootstocks.

613 P3 287
LIGHT PENETRATION AFFECTS COLOR AND FLAVOR OF 'RED DELICIOUS' APPLES
 T.W. Miller*, D.S. Mattinson, B.C. Bostick, E. Fallahi and J.K. Fellman, Plant Science Division, University of Idaho, Moscow ID 83844-2339

Light has long been known to stimulate anthocyanin accumulation in apple peel, but changes in apple flavor as a result of fruit shading is poorly understood. Some growers maintain that the redder the strain, the less flavorful the fruit. An experiment was conducted to help characterize the role of light in biosynthesis of color versus flavor molecules in apple peel. Bags fashioned from 3 meshes of shade cloth were fastened around fruitlets of red delicious strains 'Starkrimson' and 'Topred' on M26, MM106, and MM111 by 21 DAFB to produce average light ranges of 100%, 41-68%, 12-30%, and < 1% of full sun incident upon the fruit. Observations from the 1993 harvest indicate that anthocyanin content of peel increased with fruit maturity and level of sunlight. Concentrations of flavor molecules were higher with low and moderate shade than with full sun, and also increased with fruit maturity. From this harvest data, it appears that apple flavor can be enhanced by lightly shading fruit without substantially reducing fruit color.

614 PB 290
FLOWER BUD POSITION DETERMINES BLOOM AND FRUIT CHARACTERISTICS IN 'ROME BEAUTY' APPLE
 Randy R. Lee and John K. Fellman, University of Idaho, Moscow, ID 83844-2339, Esmail Fallahi, University of Idaho, Parma Research & Extension Center, Parma, ID 83660-9637

The influence of flower bud position on bloom, fruit quality, and fruit maturity was investigated on 'Rome Beauty' apple (*Malus domestica* Borkh.). Limbs on trees containing spur terminal flower buds and lateral flower buds were tagged and the number of blossoms counted every three days until bloom ended. At harvest, fruit from each bud type were selected and seed number, fresh weight, fruit quality characteristics, and onset of ethylene production were measured. Spur terminal flower buds began blooming earlier, blossomed for a longer period of time, and produced more blossoms than lateral flower buds. Fruit from spur terminal flower buds had more seeds, were heavier, and contained more starch than lateral bud fruit. Lateral bud fruit had higher pressure values, due to smaller size, and higher soluble solids, due to consumption of starch reserves. Fruit color and titratable acidity were not significantly different regardless of bud position. Spur terminal fruit started producing ethylene eight days later than lateral bud fruit, indicating they were maturing less quickly. Cultivars such as 'Fuji', 'Gala', and 'Braeburn' display similar growth and fruiting habits.

615 PB 293
BAGGING APPLE TREE LEADERS INCREASES LATERAL SHOOT DEVELOPMENT
 Matt J. Stasiak and Teryl R Roper*, Peninsula Agricultural Research Station and Dept. of Horticulture, University of Wisconsin-Madison, Sturgeon Bay, WI 54235

Inadequate branch production on apple trees can result in reduced bearing surface and problems with tree training. We sought to increase the number of lateral shoots by enclosing the one year old portion of the central leader of two year old 'Jonamac', 'Red Jonagold', and 'Scarlet Gala', apple trees two weeks prior to bud emergence. The bags were then removed when the longest shoots in the bag were approximately 2.5 cm long. After leaf fall the number and length of shoots in the bagged sections were measured. The number of lateral shoots >5 cm in length produced on the bagged sections of the leaders was increased by 3.7. Total lateral growth on the central leader increased by 149 cm per tree. Trunk cross-sectional area, tree height, or production of lateral shoots >5 cm were not affected by bagging. Differences between clear and orange bags were not significant. Bagging appeared to be an efficient means to induce trees to produce lateral branches. The greatest benefit would be to varieties like 'Jonamac' and 'Red Jonagold' which averaged only 1.7 laterals without bags.

616 PB 296
GROWTH RESPONSES OF VERTICAL APPLE SHOOTS BENT WITH BRANCH BENDER OR A HAND-TOOL. Alvan Gaus* and Matthew Rogoyksi, Rogers Mesa Research Center, Colorado State University, 3060 Hwy 92, Hotchkiss, Co. 81419.

The main objective of this research was to compare the growth responses of 1-year-old, vertical, apple shoots to bending with a simple hand-tool (HT) or bending with the commercially available Branch Bender® (BB). Single, vigorous, vertical shoots of 'Red Chief Delicious' (RCD), 'Valnur' Jonathan (VJ), and Granny Smith were either bent with the BB or were bent by spirally wrapping the shoot around a 2.5 cm diameter plastic-rod, HT 2 times. Each variety had nine single-tree blocks with a control, BB, and HT as treatments. Measurements were taken on the number of clusters formed, length of subsequent terminal growth, number of shoots and spurs formed, and shoot cross-sectional area. No differences were found in RCD between the BB and the HT on all parameters; however, terminal growth was less with the BB than the control. With VJ, first year shoot cross-sectional area for the BB was less than for the HT. Cluster formation on both 1 and 2-year-old wood was greater with the BB than the control but not with the HT. No differences were found with Granny Smith.

617 PB 299
UVM Apple Fruit Quality Testing: An Efficient Procedure for Measuring and Recording Data J.M. Clements, W.P. Cowgill, Jr.* and J. F. Costante Rutgers Cooperative Extension of Hunterdon County, 4 Gauntt Place, Flemington, NJ 08822

An accurate and efficient system for measuring and recording fruit quality data was developed. Utilizing this procedure and custom made instrumentation, two individuals can efficiently collect, measure and record the following data: apple fruit size (weight and diameter), % red skin color, length/diameter ratio, flesh firmness, soluble solids, seed count, and starch-iodine index at a rate exceeding 60 fruit/hour. If starch iodine and seed counts are eliminated, 100 fruit/hour rates can be achieved. One individual can test 40-50 fruit/hour.

Testing equipment/materials consist of a mechanical weight scale; custom made length/diameter ratio gauge; custom made flesh firmness instrumentation; refractometer; starch-iodine solution and pie pans; and an electronic data-logger. All data is manually entered. The use of custom equipment constructed from readily available parts combined with the UVM Fruit Testing Protocol, has greatly enhanced the speed and accuracy of testing, measuring and quantifying apple fruit quality data.

618 PB 322
CRYOPRESERVATION OF COLD-TENDER APPLE, *Malus domestica* Manfredo J. Seufferheld,*¹ Cecil Stushnoff and Philip Forsline², ¹Department of Horticulture, Colorado State University, Fort Collins, CO 80523. ²USDA-ARS National Clonal Apple Repository, Geneva, NY

Cryopreservation of mature dormant vegetative buds is a useful method to preserve germplasm of a large number of cold hardy apple cultivars. However, cold tender cultivars have proven to be much more difficult to cryopreserve. Eight cultivars were harvested in September 1993 at Geneva, NY before developing cold hardiness naturally. The twigs were encapsulated with 5% alginate and treated with stepwise imbibition of 0.5 to 1.0 M sucrose. The samples were desiccated over glycerol at 0C. Half of the samples were plunged directly into liquid nitrogen (LN) and the other half were first cooled slowly to -30C. The twigs that had been exposed to prefreezing conditions showed the highest survival (20 to 100%). The samples that were plunged directly in LN survived poorly (0 to 20 %). Samples without encapsulation and no sucrose imbibition had 0% survival. We conclude that this protocol opens up the possibility to expand cryopreservation of cold tender apple cultivars, presently grown only in field gene banks, at great expense and inconvenience.

Respiration as an indicator of health in excised, dormant vegetative apple buds subjected to cryopreservation treatments. L.E. Towill* and S.A. Blackman, USDA-ARES, National Seed Storage Laboratory, Port Collins, CO 80524

cryopreservation of dormant, vegetative apple buds at the National Seed Storage Laboratory is used to maintain a base collection for germplasm held in the National Clonal Germplasm Repository for apple and grape, Geneva, NY, and is performed by a method previously reported. Growth of buds after grafting is now used to test for survival after exposure to and storage at very low temperatures (ca. -160°C). We are interested in determining if measures of respiration can be used to assess 1. the status of buds and bark used for preservation, 2. survival after different treatments related to cryopreservation, and 3. the extent of sublethal injury after treatments. A Licor 6252 CO₂ analyzer was used to measure respiration. Reproducible measurements of respiration required at least 2-3 buds. Buds from winter harvested twigs (ca 45-48% moisture content) that were briefly warmed to room temperature respired at a rate of 34 $\mu\text{moles CO}_2\text{g}^{-1}(\text{dw})\text{hr}^{-1}$. Survival of buds is enhanced if twigs are dried prior to cooling. We found such treatments reduced respiration over non-dried controls. Respiration increased as the bud was rehydrated. Buds from dried twigs slowly cooled to low temperatures had levels of respiration after warming and rehydrating similar to undried, unfrozen controls. Buds from undried twigs directly placed at -196°C and warmed gave little CO₂ production.

¹ Forsline, P.L., C. Stushnoff, L.E. Twill, J.W. Waddell and W.F. Lamboy. 1993. Pilot project to cryopreserve dormant apple (*Malus* sp.) buds. Hortscience 28:478.

620

PB 328

MATHEMATICAL MODELLING OF INTERTREE SHADING IN HEDGEROW AND NON-INTERSECTING CANOPY ORCHARD SYSTEMS AND ITS IMPLICATIONS ON OPTIMAL ORCHARD DESIGN

Jeffrey W. Burcaw, Bruce W. Wood*, and Michael W. Pool. USDA/ARS, Southeastern Fruit and Tree Nut Research Laboratory, 111 Dunbar Road, Byron, GA 31008.

The authors have developed a mathematical model designed for shade-intolerant tree crops which describes the amount of intertree shading in an orchard. These data are used to formulate an optimal orchard design based on shading reduction in orchards for any tree crop during any developmental window at any global location for either continuous canopy hedgerows or non-intersecting canopies for several different orchard geometries. Variables include tree shape, orchard geometry intertree spacing, row orientation, time and day of year, and geographical coordinates. Optimal orchard designs are based upon the total amount of unshaded canopy surface per unit area which each orchard configuration confers. Results indicate extensive variability of intertree shading between hedgerow and non-intersecting canopies to be largely a function of latitude, regardless of other variables.

621

PB 331

A FRUIT TREE COOLING CONTROL SYSTEM SIMULATOR

Matthew Rogoyski*, Alvan Gaus, Byron McNew, Israel Broner, and Thomas Mournay, Rogers Mesa Research Center, Colorado State University, 3060 Hwy 92, Hotchkiss, CO 81419.

A simulator of a control system for evaporative cooling of crop canopies was developed. This development, prior to implementation of an irrigation/cooling system, allowed for experimentation before committing resources to the field system. The project provided insight into problems of modeling interaction between biological, mechanical, and digital systems and demonstrated how specialists from diverse areas can solve these problems. The object orientation methodology and the C++ programming language were tools for development of this simulator. A communication mechanism was devised to facilitate interactions between software entities representing both concrete and abstract objects corresponding to the problem domain. The object-oriented approach to the system development allowed for better communication between team members, irrespective of their background in software engineering. The modular and polymorphic nature of the object-oriented code made it possible to plan for code reuse in future projects. Simulator development using the object-oriented paradigm was found to be preferable over the procedural model used by team members in other projects in the past.

79 POSTER SESSION 11 (Abstr. 622-634A)

Sustainable Agriculture: Culture and Management

622

PB 442

THERMAL WEED CONTROL FOR VEGETABLE PRODUCTION

Gagnon André Yelle Serge, Université Laval, Centre de recherche en horticulture, FSAA, Environtron, Ste-Foy, Qc, Canada, G1K 7P4.

In the summer of 1992, a 4-year research program on the utilisation of propane in agriculture was initiated between ICG Propane and Laval University. Experiments were conducted to evaluate the effects of propane burners on weed control as a pre-establishment treatment. The data indicate that the efficiency of weed control is related to tractor speed and gas pressure. When weed height is between 1 and 2 centimetres, most of the heat treatments were as effective as those with the herbicide paraquat. The best and most economical heat treatment was at a tractor speed of 6 Km-hr and a gas pressure of 65 PSI. With larger weeds, efficiency increased with reduces tractor speed and increased gas pressure. In addition, high intensity treatments provided excellent control on broadleaf weeds but were less efficient on grass species. A preliminary economical evaluation showed that propane burners are competitive with chemical herbicides and large-scale commercial trials are planned for summer 1994.

623

PB 445

ALTERNATIVES TO METHYL BROMIDE FUMIGATION IN TOMATO PRODUCTION

Sandra L. Barbour*, Kathy H. Brock, B.A. Fortnum, and Dennis R. Decoreau, Horticulture Department, Clemson University, Clemson, SC 29634.

Pest control-related problems jeopardize the advancement of our nation's vegetable industry. Because of the adverse effects of many fumigants, the grower is increasingly pressured to utilize sustainable, environmentally sound agricultural practices yet still maintain a marketable, blemish-free product.

The effects of wavelength selective mulches and three different fumigants on overall plant development and nematode control were studied in field grown, staked tomatoes. Plots were fumigated with methyl bromide, Telone II, or Telone C17. Within rows, mulch color was established by application of either white or red exterior enamel paint to the black plastic surface of polyethylene mulch. Reflective light from each mulch color was measured using a LiCor 1800 Spectroradiometer. Temperature below the mulch surface was monitored with a datalogger.

Prior to the first marketable harvest, plants grown on white mulch produced greater fruit weight and total dry weight than plants grown on black or red mulch. Total marketable yields, however, were not significantly different between the three mulches. Early and marketable yields from fumigated plots did not differ from control treatments. The lack of response due to fumigation may have been due to low initial nematode populations in the field.

624

PB 448

SHORT- AND LONG-VINE PUMPKINS INTERCROPPED WITH BEANS AND COWPEAS.

P. Chesney, L. Wessel-Beaver*, G. Elmstrom, and D. Maynard, Univ. of Puerto Rico, Mayaguez, PR 00681, Univ. of Florida, Leesburg and Univ. of Florida, Bradenton

Rows of tropical pumpkins (*Cucurbita moschata*) are typically spaced 3-4 m apart Rows fill in 8 to 10 weeks after planting, potentially allowing a short-seasoned intercrop to be planted. A long-vine cultivar (PRB-150) and a short vine genotype (FL-I25xI21 - winter planting; FL-I25 - fall) were planted 0.9 m within rows by 1.8 between rows in Lajas and Isabela, PR in winter and fall of 1993. Either beans, cowpeas or no intercrop were planted on the same date as the pumpkin maincrop. Legume plots were harvested both green-shelled and dry. Pumpkin canopy cover, yield, fruit number and size were the same in intercropped and non-intercropped plots These same traits

varied significantly in short vs. long vine plots (short vine plots were lower yielding with smaller fruits and less canopy cover). Plots planted with the short-vine maincrop generally produced greater legume yields. Harvest of dry beans or cowpeas was nearly impossible in long vine plots since the canopy covered the legume plants at that stage. Intercropped green-shelled bean yields averaged 800 kg/ha. Such a yield would add substantially to the income of the pumpkin maincrop.

625

PB 451

RESPONSE OF TOMATOES AND BEANS, GROWN IN ROTATION, TO THREE YEARS OF COVER CROP AND NITROGEN TREATMENTS

Jeanine M. Davis*, Mtn. Hort. Crops Research & Extension Center, Dept. of Horticultural Science, North Carolina State University, 2016 Fanning Bridge Road, Fletcher, NC 28732.

In 1991, a four year study was initiated in which staked tomatoes and snap beans are rotated annually and grown with three cover crop treatments (wheat, crimson clover, and bareground) and three N rates (0, 60, and 120 kg N/ha) in a RCB with four replications. Crop growth, yield, nutrient status, N cycling, and pest populations are being studied. The first year there was no response to cover crop. The next two years, crimson clover reduced bean yields due, in part, to high levels of disease. Mexican bean beetle populations were also highest with clover and increased with increasing N rate. In 1992, wheat increased tomato fruit crack, but there was no effect on yields. In 1993, wheat reduced early season tomato yields but had no effect on total season yields. Aphid populations were highest on tomatoes grown with crimson clover. The study reveals that cover crop systems are dynamic and long-term studies are required before dependable grower recommendations can be made. This study is part of the Tri-State Vegetable Project, a cooperative research project with N.C., S.C. and Ga.

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PB 454

ECONOMIC COMPARISONS OF SUSTAINABLE AND CONVENTIONAL EGGPLANT PRODUCTION TECHNOLOGIES IN SOUTHERN GEORGIA

Kathryn E. Brunson¹*, C. Robert Stark, Jr.², Sharad C. Phatak¹, Michael E. Wetzstein,^{3,4} The University of Georgia, Tifton, GA 31793, ¹NESPAL, The University of Georgia, Tifton, GA 31793, ²Dept. of Agricultural And Applied Economics, The University of Georgia, Athens, GA 30602.

Research results are presented of a multi-year study on eggplant in Southern Georgia comparing two sustainable production technologies to the conventional rye cover crop technology. The sustainable technologies utilize beneficial insect principles as a substitute for conventional pesticide controls. Preliminary results from the sustainable technologies using crimson clover and subterranean clover indicate that the higher yields under rye can be more than offset by cost reductions associated with selected sustainable technologies. Production budgets are developed for eggplant to indicate expected net returns under both the sustainable and conventional technologies

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PB 457

RELAY-INTERPLANTING COVER CROPS IN SWEET CORN

Tom TenPas and John Luna, Dept. of Horticulture., Oregon State University, Corvallis, OR, 97331

The effect on corn yield of interplanting two different cover crops, *Trifolium repens*, and *Lolium perens* into sweet corn, *Zea mays*, at 4 different times from corn planting was examined. Sweet corn was planted in 30 inch rows, and the cover crop was planted 0, 7, 14, and 21 days afterwards. The study was designed as a complete randomized block experiment with 4 replications. Weed management practices included pre-emergent herbicides and cultivation only treatments.

No significant yield differences in corn yields were detected ($\alpha=0.05$). Most of the plots had very little weed competition, including those with no herbicide treatment. Earlier planted cover crops were better established at time of corn harvest. Additional work is needed to examine this practice in conditions of greater weed competition.

628

PB 478

Trees, Crops and Soil Microbes Interact In Alley Cropping Systems

Stefan Seiter*, Ray William, Department of Horticulture, Oregon State University, Corvallis, Oregon

Red alder (*Alnus rubra* Bong) and black locust (*Robina pseudoacacia* L.) were intercropped in different planting patterns with sweet corn (*Zea mays* L.) in Corvallis, Oregon. In both years, sweet corn yield in alley cropping systems was significantly reduced when trees occupied more than

20 % of the total area. In the first year, higher yield were harvested in corn rows adjacent to the trees which compensated for reduced cropping area in the alley cropping systems. Low sweet corn yield coincided with high pruning biomass production. Red alder pruning biomass was small in the first year but equivalent to black locust in the following year. In the second year, soil microbial counts at planting time showed that bacterial and fungal activity in the tree rows was significantly higher compared to corn rows. At corn harvest, fungal activity was higher in tree rows and in corn rows adjacent to trees compared to corn rows more distant to the trees or corn rows in monocropping systems. It might be that higher sweet corn yield in rows next to the trees not only are the result of an increase in the amount of intercepted light but that below ground effects such as nitrogen mineralization from increased microbial activity or nitrogen transfer from the trees to the crop play an important role.

629

PB 481

RESPONSE OF VEGETABLES, N SOURCES AND FALL COVER CROPS ON YIELDS, N ACCUMULATION AND SOIL INORGANIC N

Wilbur C. Anderson and Shiou Kuo, Washington State University Mount Vernon Research and Extension Unit, 1468 Memorial Hwy, Mount Vernon, WA 98273

Broccoli, potatoes, cucumbers and green peas were fertilized respectively with 241, 168, 168 and 28 kg N ha⁻¹. The N accumulation was equivalent to the fertilizer application rates for the broccoli, potatoes and cucumbers while the peas accumulated 321 kg N ha⁻¹. Vegetable yields were not affected by previous cereal rye cover crops when compared to the fallow control. Cover crops following broccoli accumulated the least and peas the most N. Inorganic N in the top 30 cm at harvest were significantly different between vegetables, but not in the 30-60 cm depth.

Chicken manure and ammonium nitrate as N sources were compared. Broccoli was the test crop and was fertilized with both sources at 241 kg N ha⁻¹. Broccoli yields and N accumulation were different between sources of N and between N and no-N treatments. Inorganic N leaching was greatest with ammonium nitrate fertilization and chicken manure was similar to the no-N fertilizer treatment.

630

PB484

AN ORGANIC VS. CONVENTIONAL FARMING SYSTEM IN KIWIFRUIT

Janine K. Hasey*, R. Scott Johnson, Roland D. Meyer, Karen Klonsky, University of California Cooperative Extension, 142-A Garden Highway, Yuba City, CA 95991.

A kiwifruit vineyard converted to an organic farm was compared to a conventionally farmed vineyard from 1990 through 1992. February or March applications of composted chicken manure (organic plot) or NH₄NO₃ plus CaNH₄(NO₃)₂ through microsprinklers during the growing season (conventional plot) were applied to give equal rates of N. Soil analyses indicated no differences in nutrient or salt levels. Nitrogen leaf levels from the organic plot were consistently lower than those from the conventional system but were not deficient. Leaf concentrations of sodium and chloride increased over the three-year period in the organic plot, but not to phytotoxic levels. Organically grown fruit was as firm or firmer than conventionally grown fruit at harvest and four months after harvest. Damage from latania scale or omnivorous leaf roller was minimal in both plots until 1992, when the organic plot had 3.9% scale compared to 0% in the conventional plot. An economic analysis comparing the short-term profitability of the two systems will be presented.

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PB 487

ROOT ARCHITECTURAL RESPONSE OF BELL PEPPER TO SOIL AMENDMENTS

Robert H. Snyder*, Terry Schettini², and Jonathan P. Lynch¹, ¹Penn State, University Park, Pa 16841, ²Rodale Institute Research Center, Kutztown, Pa., and Donald Kaufman, USDA/ARS³.

Sustainable agricultural systems favor high organic amendments over chemical fertilizers for maintaining long-term soil fertility. To study root responses bell pepper was grown in soil treated with dairy compost, raw dairy manure, and a chemical fertilizer mix at Rodale Institute Research Center, Kutztown, Pa. Root crowns were excavated at 2-week intervals and total length determined from root subsamples by computer-based image analysis. Roots from compost amended plots displayed a simple branching pattern; a first order branch with short second order branches. Fertilizer stimulated a complex branching; short, thickened first and second order branches that supported long and thin third and fourth order

roots. An **intermediate** form in the **raw dairy** plots yielded both simple and complex branching forms. All forms were dynamic within each treatment over time. Crown length averaged 250-300 m across treatments 6 weeks after transplanting. Raw dairy and fertilizer treatments decreased slightly in length by week 10, while compost remained constant. After heavy rainfall crown length increased to 400 m for compost and raw dairy, and to 750 m for the fertilizer treatment by week 13. Length for the fertilizer treatment dropped nearly 200 m by week 14, though an increase of 100-200 m occurred for compost and raw dairy treated roots respectively.

632

PB 490

FIELD TRIALS WITH COMPOSTED, PELLETIZED POULTRY LITTER APPLICATIONS IN SPINACH AND COLLARDS

Tina Gray Teague*, Arkansas State University, State University, AR 72467

On farm studies in 1994 with a composted, poultry litter (PPL) product, Organigro (Organigro Inc., Watts, OK), were conducted with fall spinach and collards in eastern Arkansas. In a small plot study with 'Cascade' spinach grown on Dubbs fine sandy loam soil (pH 6.5 to 6.8) in a large commercial field receiving fertilizer inputs of 102 -0.70 NPK + 29.5 S + 0.5 B, additions of as little as 280 kg PPL ha⁻¹ significantly increased yield. In collard studies, effects of applications of PPL, NPK and a transplant water applied fertilizer solution were compared in a trial with transplanted 'Blue Max' grown in a silt loam soil (pH 5.8 to 6.2) that had been damaged from precision leveling. PPL applied at 560 kg ha resulted in significantly higher yields than plots receiving NPK (applied as 516 kg 13-13-13 ha⁻¹) alone. Applications of a fertilizer solution containing secondary and micronutrients (Golden Harvest Plus, Smeller Chemical, Houston, TX) in transplant water (50 ml/plant solution containing .95 l GH+/378 l H₂O) resulted in comparable yields as those treatments with PPL. These results indicate that shallow rooted vegetable crops such as spinach and collards grown in damaged soils or light textured soils with low organic matter can be improved with additions of poultry litter. The PPL product used in these studies is produced with a guaranteed analysis of 4-4-4 NPK, and because it has been composted, problems with weed seeds and pathogenic organisms have been eliminated. The pelletized form of the product also, facilitates field application. These properties make this type product ideal for use in vegetable production systems, particularly where problems with secondary or micronutrients may be likely.

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PB 493

EFFECT- OF COMPOSTED SEWAGE SLUDGE ON VEGETABLE PRODUCTION

Michael D. Orzolek* and John H. Murphy, Dept. of Hort., 203 Tyson Bldg., The Pennsylvania State University, University Park, PA 16802

A long term study was initiated in 1993 to evaluate the effect of composted sewage sludge on growth, yield, and quality of different vegetables. The composted sewage sludge consisting of 40% hardwood sawdust and 60% clean municipal wastewater sludge was obtained from the University Area Joint Authority (UAJA) in State College, PA. The composted sewage sludge is currently sold by UAJA as a fertilizer amendment under the name CompostT. Two rates of the CompostT product (11 and 22 dry T/A) were compared to a granular fertilizer application of 800 lbs/A of 10-10-10. The low rate of CompostT also received half of the fertilizer rate. After incorporation of the amendments into a Hagerstown clay loam soil, lettuce, tomato, muskmelon, cabbage and pepper were transplanted in the field in a Randomized Block Design with 3 replications. CompostT application did not reduce yield or quality of cabbage, lettuce, tomato, and muskmelon; in fact, yields were generally higher with the application of composted sewage sludge. The application of CompostT did not reduce the macro or micro nutrient concentration of leaf tissue below optimum levels nor did it result in any phytotoxic effects in plant growth. In addition, the application of CompostT did not increase the heavy metal (Cd, Ni, Pb) concentration in leaf tissue or increase the risk of microbial contamination in the edible portion of the vegetables.

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PB 514

POTENTIALS OF SUNN-HEMP AS GREEN MANURE IN VEGETABLE PRODUCTION IN GUAM

Mari Marutani., College of Agriculture and Life Sciences, University of Guam, UOG Station, Mangilao GU 96923

Sunn-hemp, *Crotalaria juncea* L. cv. Tropic Sun was developed in Hawaii in 1982 and recently introduced to the island of Guam by USDA Soil Conservation Service as a potential green manure crop. An evaluation of various legumes at three different soil regimes revealed that sunn-hemp produced greater biomass than other plants. In the study of the effects of sunn-hemp in subsequent vegetable production, slightly greater canopy was observed for potato, *Solanum tuberosum* cv. Kennebec, with green manuring with sunn-hemp than without. Yield of head cabbage, *Brassica oleracea* var. capitata cv. KK Cross, was higher with green manuring (1085.5g/head) than without (725.4g/plant). Competition between indigenous rhizobia and introduced inoculant seems to exist at some locations. Major constraints in using sunn-hemp as green manure on the island are its limited seed sources and requirements of additional labor. Education and promotion of using this legume in a long term soil-improving system is needed.

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PB 527

INSECT PEST MANAGEMENT THROUGH A CABBAGE-INDIAN MUSTARD COMPANION PLANTING

David A. Bender* and William P. Morrison, Texas A&M University System Agricultural Research and Extension Center, Lubbock, TX 79401-9757

Indian mustard (*Brassica juncea*) has been reported to be a preferred host for diamondback moth (*Plutella xylostella*) and other insect pests when interplanted with cabbage (*Brassica oleracea* var. capitata). A cabbage-Indian mustard companion planting study was conducted to determine the seasonal occurrence of cabbage insects and the potential for using a trap-crop system to reduce insecticide applications to cabbage in West Texas. Three-row plots of cabbage 9 m long were transplanted with and without sequentially seeded borders of Indian mustard in three seasons. Harmful and beneficial insects were counted at roughly weekly intervals. Insecticides were applied when insect populations in individual plots reached predetermined thresholds. Indian mustard did not appear to be more attractive than cabbage to lepidopterous pests, but did preferentially attract hemipterans, particularly harlequin bugs (*Margantia histrionica*). The mustard trap crop eliminated two insecticide applications in one trial by reducing harlequin bug pressure on the cabbage.

80 POSTER SESSION 12 (Abstr. 635-649) Crop Protection

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PB 334

HISTOCHEMICAL LOCALIZATION OF LIPOXYGENASE, PEROXIDASE AND POLYPHENOL OXIDASE IN POTATO TUBER TISSUE

Steven F. Vaughn, USDA, Agricultural Research Service, National Center for Agricultural Utilization Research, Peoria, IL 61604

Localization of enzymes in specific plant tissues is crucial to understanding their role in processes such as differentiation and disease resistance. The oxidative enzymes lipoxygenase (LOX; EC 1.13.11.12), peroxidase (PER, EC 1.11.1.7) and polyphenol oxidase (PPO; EC 1.10.3.1) have all been implicated as playing critical roles in plant disease resistance. The histochemical localization of all three enzymes in potato tuber slices was accomplished either directly on the tissue slices (for LOX) or by blotting of the tissue onto nitrocellulose membranes (for PER and PPO). LOX was visualized in specific tissues by the oxidation of KI to I₂ via lipid peroxides and the subsequent reaction of I₂ and endogenous starch to form a colored, insoluble complex. PER and PPO activities were visualized with 4-methoxy- α -naphthol and 3,4-dihydroxy-phenylalanine, respectively. Fractionation of the slices and determination of enzyme activities in the fractions confirmed the reliability of these techniques.

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PB337

POLYGALACTURONASE INHIBITOR IN BEAN PODS

Russell Pressey, Richard B. Russell Agricultural Research Center, USDA, ARS, P.O. Box 5677, Athens, GA 30613

Polygalacturonase inhibitors have been reported in a number of dicotyledonous plant tissues including pear and raspberry fruits and bean seedlings. These proteins inhibit fungal polygalacturonases and thus have been implicated in disease resistance in plants. The earlier work on the inhibitor from bean plants was conducted with hypocotyls as the source. We have found that immature bean pods contain much more inhibitor than other parts of the plant and developed a procedure for purification of this inhibitor. Fresh bean pods were extracted with 1.0 M NaCl at pH 7 and the proteins were precipitated with ammonium sulfate. The proteins were dissolved, dialyzed and chromatographed on a column of S-Sepharose. The inhibitor from this step was then chromatographed on a Mono Q column at high pH. Yields of the inhibitor varied somewhat with bean cultivar and pod maturity but were about ten times higher than from hypocotyls. The purified inhibitor reacted optimally with *Aspergillus niger* endopolygalacturonase at pH 4.3 and appeared to be similar to the inhibitor from hypocotyls. Bean pods thus are a convenient source of polygalacturonase inhibitor for studies on fruit maturation and disease resistance in plants.

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XANTHOMONAS CAMPESTRIS PV. VESICATORIA INCREASES METHANOL AND ETHYLENE EVOLUTION FROM PEPPER LEAVES
Jeffrey A. Anderson¹, Niels O. Maness¹ and Robert E. Stall², Dept. of Horticulture and L.A., Oklahoma State Univ., Stillwater, OK 74078 and ²Dept. of Plant Pathology, University of Florida, Gainesville, FL 32611

Bell pepper (*Capsicum annuum* L.) leaves inoculated with Race 1 of *Xanthomonas campestris* pv. *vesicatoria* (XCV) produced more ethylene and methanol than water-infiltrated controls in studies with leaves attached or detached during inoculation and dissipation of water-soaking. 'Early Calwonder 20R', a pepper genotype resistant to Race 1 of XCV, evolved more ethylene and methanol than 'Early Calwonder 10R' (susceptible) following syringe inoculation of detached leaves with $\approx 7 \times 10^7$ cells/ml. A light intensity of $\approx 500 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ during dissipation of water-soaking of attached leaves triggered more ethylene and methanol than covering inoculated leaves with aluminum foil. Volatile hydrocarbon production from leaves infiltrated with distilled water was not significantly affected by light intensity during dissipation of water-soaking. The lipid peroxidation products, ethane and pentane, were not detected by headspace sampling following bacterial inoculation.

EFFECTS OF PHENOLIC METABOLISM ON SUSCEPTIBILITY OF PEACH ROOTSTOCKS TO NEMATODES

Yuan Yongbing*, A. M. Simeone and P. Cappelini, Laiyang Agricultural College, Shandong, China, and Istituto Sperimentale Per La Fruitticoltura, Roma, Italy

Peach rootstocks Rancho Resistant (RR) and GF 677 are resistant and susceptible to nematodes, respectively. One-year-old seedlings of RR, GF677 and their reciprocal grafts were inoculated with 10,000 larvae. Both inoculated and control plants were harvested at intervals for assay. Phenylalanine ammonia lyase (PAL) activity and soluble phenol content were enhanced in both RR and GF677 after inoculation, but RR always had a 2-fold higher peroxidase (PO) activity than GF677. When GF677 was grafted on RR, the resistance of RR was not altered. When RR was grafted onto GF677, the number of galls on the plant were 66% and 77% less than on GF677 2 weeks and 2 months after inoculation, respectively. However, no interaction was found in the reciprocal graft. The results showed that higher soluble phenol content and PAL activity induced by nematode attack were common features of RR and GF677, and a positive relation between PO activity and resistance to nematode existed in the two rootstocks.

RELATIONSHIP BETWEEN THE SURFACE WAX OF APPLE FRUIT AND SOOTY BLOTCH DISEASE

R.D. Belding*, T.B. Sutton, and S.M. Blankenship, North Carolina State University, Box 7609, Raleigh NC 27695-7609

Apple sooty blotch (SB) is a disease complex caused by *Gloeodes pomigena* (Schw.) Colby, *Leptodontidium* sp. and other fungi. This study was undertaken to determine if *G. pomigena* and *Leptodontidium* sp. utilize some portion of the apple epicuticular wax as a carbon source for growth. Two isolates of *G. pomigena* and two of *Leptodontidium* sp. were used. Isolates were cultured on water agar coated with a thin layer of either nonacosane, ursolic acid, or complete apple wax and an uncoated control. Radial colony growth over a 30-day period was used to assess growth. Preliminary results suggest that *G. pomigena* differs from *Leptodontidium* sp. in carbon source preference. *Gloeodes* colonies were larger when ursolic acid and apple wax were used as a carbon source compared to nonacosane. *Leptodontidium* isolates grew best on apple wax. Also, growth was greater on nonacosane than ursolic acid. results from laboratory studies were compared to SB severity (percent surface area covered) in the orchard on cultivars of apples where the wax composition was determined. Although fungal genera were not detailed in the orchard, SB severity was positively correlated with the concentration of ursolic acid ($r^2=0.69$) and nonacosane ($r^2=0.34$).

FALL COLE CROP PRODUCTION FOLLOWING TOBACCO

A.M. Clements* and L. A. Weston Department of Horticulture & Landscape Architecture, University of Kentucky, Lexington KY 40546-0091

Fall cole crops of exceptional quality and high market value are produced in Kentucky. Tobacco is an integral part of agriculture in the southeastern states and production of fall cole crops following tobacco may increase diversification and Potential profits. A float system was utilized for transplant production. Field plots were established with broccoli and cabbage grown conventionally, planted into killed sudex cover, cultivated

tobacco stubble and directly into tobacco stubble. Data were collected on soil fertility, insect and weed populations, crop quality and yield. Periodically, foliar samples were analyzed for nitrate, total nitrogen, phosphorus, potassium and calcium content. Fall cole crops grown conventionally or in killed sudex cover produced comparable results and head size. Insect pressures were reduced in killed sudex covers. Total yield and quality were reduced when seedlings were planted directly into tobacco stubble.

CHALLENGES IN IMPLEMENTING A BIOINTENSIVE IPM PROGRAM IN DIVERSE-CROP GREENHOUSES

Philio A. Stack* and Francis A. Drummond, Department of Entomology, Univ. of Maine, Orono, ME 04469-5722

A biointensive IPM program began in 1991 in UM's 12,000 ft² research/teaching greenhouses. Efficacy, economics and practicality of multiple natural enemy releases to control greenhouse arthropod pests in diverse-crop ranges were assessed in 1991-93. Both UM lab-reared and commercial insectary-produced natural enemies were used. Environmental constraints, natural enemy quality, daylength and short crop cycles limited biocontrol. Predators and parasites were most effective when compatible environmental parameters, cultural practices and biorational pesticides were used. Informing greenhouse users about natural enemy recognition and conservation were also important considerations. Rearing and release techniques and compatible systems are discussed.

EVALUATION OF ALTERNATIVE FUMIGANTS FOR TOMATO PRODUCTION

Stephen M. Olson* and Joe W. Noling² North Florida Research and Education Center, Quincy, Florida, ²Citrus Research and Education Center, Lake Alfred, Florida.

Methylbromide is the standard fumigant used for tomato production in Florida. Since it been classified as a category 1 ozone depleter and is to be phased out by 1 Jan 2001 replacement methods of fumigation must be found. Several materials in 1993 were compared to methylbromide in production of 'Colonial' tomatoes. These included metham sodium (applied through drip at 3 rates and applied to soil at 935 l-ha⁻¹ and tilled in), dazomet (applied at 2 rates and tilled in), 1,3 dichloropropene + chloropicrin and untreated check. None of the treatments were as effective as methylbromide in reducing root galling by root knot nematodes. Total yields were not affected by treatments even though root system of untreated plants was severely galled. Modifications are to be made for 1994 season and materials added to trial.

TRAP CROP AND GENOTYPE EFFECT ON DIAMONDBACK MOTH POPULATION DYNAMICS IN HEAD CABBAGE

Hector R. Valenzuela*, Joseph DeFrank, and Greg Luther, Dept. of Horticulture, 3190 Maile Way, University of Hawaii at Manoa, Honolulu, HI 96822.

The diamondback moth (DBM), *Plutella xylostella*, is the number one pest of cabbage in the world. The pest is resistant to most pesticides registered for its use, and resistance has also been detected in several areas for registered biopesticides. Four experiments were conducted to: 1) Determine the tolerance to DBM feeding among 20 commercial head cabbage cultivars, 2) Evaluate the effect of three nitrogen fertility levels on DBM numbers, and 3) Evaluate the effect of Indian mustard. Brassica juncea trap crops as a tool to manage DBM populations in head cabbage agroecosystems. Experiments were conducted at University of Hawaii experiment stations located in Kamuela, Hawaii, and in Kula, Maui. The trap crop treatments consisted of planting two border rows of Indian mustard in cabbage field borders. Three or 4 biweekly insect counts were conducted for each trial. Insect counts consumed of destructive sampling of 3-6 plants per plot and determination of larvae and pupae number and parasitism levels. The nitrogen studies found more DBM in monoculture cabbage receiving 300 kg Ha⁻¹ N than in controls even though cabbage yields did not vary among treatments. A range of tolerance to DBM feeding was found among the cultivars tested. The trap crop system was shown to be more effective during the summer than in the winter months. Data indicates that the trap crop also acted as attractant for beneficial insects, which may aid in the biological control of DBM in cabbage

SELECTION OF MICROORGANISMS FOR BIOLOGICAL CONTROL OF *FUSARIUM SPP.* IN ASPARAGUS

Marshall K. Elson*, John F. Kelly and Muraleedharan G. Nair, Department of Horticulture, Michigan State University, East Lansing, MI 48824

Actinomycetes were isolated from asparagus field soil and bioassayed against *Fusarium spp.* in petri dishes. Extracts of the active organisms were bioassayed to determine if inhibition was caused by competition or antibiosis. The most active, antibiotic-producing organism was inoculated into test tubes with asparagus and *Fusarium* and evaluated for disease control. Asparagus seedlings were dipped in actinomycete suspension before planting in *Fusarium*-infested soil. These seedlings were evaluated for disease incidence after 8 weeks. Asparagus crowns could be dipped in actinomycete suspension before planting in the field.

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PB 407

FIELD STUDY OF BLACK SPOT RESISTANCE IN ROSE

William A. Black*, David H. Byrne, and H. Brent Pemberton, Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

Forty-five rose genotypes including modern cultivars and rose species were evaluated in a field trial for resistance to black spot caused by *Marssonina rosae*. The trial was designed as a randomized block with four replications at two sites. The plots were planted at College Station (East Central Texas) and Overton (Northeast Texas). Ratings were done for the percentage of leaflets with black spot lesions and for leaf defoliation. These ratings were taken four times during the growing season from May to October 1993. Preliminary results indicate a high degree of resistance in the ten species studied. Modern cultivars were equally divided into moderate resistance, low resistance, and susceptible with only four showing high resistance. Disease pressure was higher and occurred earlier in the season at the Overton site. Disease pressure was highest at both sites in late spring and again in fall. Pressure was lowest in August after a prolonged period without rain. Introduction during the growing season of a previously unseen race of the pathogen was observed by the performance of the cultivar Sunbright.

RESISTANCE TO *BOTRYTIS CINEREA* IN PETUNIA

Kimberly H. Krahling* and William M. Randle, Department of Horticulture, University of Georgia, Athens, GA 30602

Botrytis diseases are the most common and among the most destructive diseases affecting greenhouse-grown crops. Presently a combination of cultural control and fungicidal sprays are used to control the disease. Increasing energy and labor costs plus evidence of resistance of *B. cinerea* strains to commonly used fungicides has made the disease more difficult to control. A source of genetic resistance would provide an additional powerful and stable tool to control the incidence of *Botrytis* disease.

In this study screening techniques for *Botrytis* resistance in petunia were developed and 40 petunia genotypes were screened for resistance to *B. cinerea*. A wide range of variability for resistance to *B. cinerea* was discovered in petunia. Results indicate the presence of useful quantitative-type resistance to *B. cinerea* in petunia.

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PB 413

REACTION OF POTATO CV. BELRUS TO INFECTION WITH POTATO LEAFROLL VIRUS

Robert W. Goth, Ernest W. Goins* and Kathleen G. Haynes. USDA-ARS, Vegetable Laboratory, Beltsville, MD 20705

Potato leafroll virus (PLRV) is a serious aphid transmitted virus disease of potato (*Solanum tuberosum* L.). Field observations suggest that the cv. BelRus is tolerant to PLRV. Greenhouse grown BelRus and PLRV susceptible potato cvs. Green Mountain and Katahdin were tested for PLRV with enzyme linked immunosorbent assay (ELISA) and subsequently infested with PLRV infected green peach aphids (*Myzus persicae*). ELISA was used to test leaves from the top, middle and bottom portion of the plants at 7 day intervals beginning 7 days after aphid infestation. PLRV was detected in all tested locations of the Green Mountain and Katahdin plants 21 days after inoculation. In BelRus, throughout the 11 week test, PLRV was detected predominantly in the top portion of the plants and at low titres. These results suggest that tolerance to PLRV infection in the cv. BelRus may be due to suppression of virus replication.

Mountain and Katahdin plants 21 days after inoculation. In BelRus, throughout the 11 week test, PLRV was detected predominantly in the top portion of the plants and at low titres. These results suggest that tolerance to PLRV infection in the cv. BelRus may be due to suppression of virus replication.

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PB 416

MINIMAL USAGE OF CARBAMATE FUNGICIDES IN FIELD PRODUCTION OF SPINACH AND POSTHARVEST REMOVAL OR RESIDUES BY WASHING TECHNIQUES.

Alfredo R. Gonzalez*, James C. Carrel, and Dennis Motes, University of Arkansas, Department of Food Science, Fayetteville, AR 72703.

A study was conducted to test alternative production practices that lessen the use of carbamate fungicides in the field and post-harvest washing techniques that help to reduce carbamate residues in canned spinach. Five spinach genotypes showed a high degree of resistance to white rust, the predominant field disease. The fungicide Ridomil used alone or combined with copper or Maneb provided the best control in susceptible cultivars. Maneb alone or combined with copper controlled white rust but not as efficiently as Ridomil. The most efficient washing methods to remove Maneb residues were washing with a detergent solution plus water or ozonated water or a triple wash with detergent, water and ozonated water. The lowest residue levels of ethylenethiourea (ETU), a carcinogenic carbamate derivative, detected in the washing treatments was in the range of 0.15 to 0.45 ppm. ETU in the non-washed controls fluctuated from 0.85 to 2.31 ppm.

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PB 419

UTILIZATION OF XYLEM FLUID DURING DEVELOPMENT BY THE LEAFHOPPER VECTOR HOMALODISCA COAGULATA

Brent V. Brodbeck, Peter C. Andersen and Russell F. Mizell, III, Univ. of Florida, NFREC-Monticello, Rt. 4, Box 4092, Monticello, FL 32344

Homalodisca coagulata (Say) is a xylem feeding leafhopper that is the principal vector of many economically-important diseases resulting from infection by *Xylella fastidiosa* (i.e., plum leaf scald, phony peach disease, Pierce's disease). Xylem fluid consists primarily of dilute concentrations of amino acids, organic acids and inorganic ions, and thus provides less nitrogen and carbon for herbivorous insects than any other plant tissue. Despite these nutritional constraints, *H. coagulata* is highly polyphagous. To assess how *H. coagulata* subsists on this dilute food source we examined host utilization by different instars on *Lagerstroemia indica* L. (preferred adult food source) and *Euonymus japonica* Thunb. (preferred ovipositional site).

Different instars survived and utilized nutrients at varying rates on the two hosts. Second instar nymphs survived at higher rates on *E. japonica* and utilized nitrogen more efficiently than on *L. indica*, yet assimilated nitrogen was less as a result of lower feeding rates. Adults on *L. indica* were more successful than those on *E. japonica*, used carbon more efficiently, and assimilated higher quantities of both carbon and nitrogen. Efficiencies of nutrient utilization were high for *E. coagulata* compared to other types of insects with assimilation efficiencies of specific compounds often exceeding 90%.

81 POSTER SESSION 13 (Abstr. 650-658) Vegetables: Nutrition

650

PB 022

DIFFERENT LETTUCE TYPES RESPOND SIMILARLY TO P FERTILIZATION

N.M. El-Hout*, South Bay Growers, Inc., P.O. Drawer A, South Bay, FL 33493, and C.A. Sanchez, Univ. of Arizona, YAC, 6425 W. 8th St., Yuma, AZ 85364

The production of lettuce (*Lactuca sativa* L.) types other than crisphead (i.e., leaf, boston, bibb, and romaine) has recently increased due to expanding consumer demand. Fertilizer P recommendations for these lettuce types are largely based on soil-test calibrations for the crisphead type only. However, biomass production and morphological traits of the different lettuce types vary. Four field experiments were conducted to compare the relative efficiencies of these lettuce types to P fertilization. All lettuce types

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showed large yield and quality responses to P. Because environmental conditions affected yield potential, P rates required for optimal yield varied by lettuce type within experiments. However, the P rates required for optimal yield were similar over all experiments. Furthermore, the relationship between relative yield and soil-test P across all seasons showed a similar soil-test P level was required for maximum yield of all lettuce types. The results of this study show that soil-test-based fertilizer recommendations for crisphead lettuce may be adequate for all lettuce types

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PB 025

FERTILIZER BANDING REDUCES P INPUTS INTO COMMERCIAL LETTUCE PRODUCTION ON HISTOSOLS

N. M. El-Hout*, South Bay Growers, Inc., P.O. Drawer A, South Bay, FL 33493.

Band placement has been recognized as an effective strategy for improving P fertilizer-use efficiency on Histosols, which are often characterized as environmentally sensitive wetlands, and for reducing P loading of drainage waters from these soils. Recent studies indicate that crisphead lettuce (*Lactuca sativa* L.) yields can be optimized with a band-P rate one-third of that required with broadcast applications. However, such findings have not been verified in large production plots. Five field experiments were conducted between 1991 and 1993 to evaluate the response of crisphead lettuce produced commercially on Histosols to band P rates. Liquid P fertilizers were placed in 10-cm-wide strips, 8.5-cm below the seed at planting in rates ranging from 0 to 224 kg P ha⁻¹. Lettuce yields increased significantly with P rate in all experiments. Irrespective of initial soil-test-P index, lettuce yields within each experiment were maximized with a band rate 54% of that required in a broadcast. The pooled data for all experiments showed a similar trend. These findings provided a means of making alternative band fertilizer recommendations by utilizing an existing preplant broadcast soil test.

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PB 028

COMPUTER ANALYSIS OF AERIAL PHOTOGRAPHS TO DETECT N STRESSES IN LETTUCE

C.A. Sanchez*, Univ. of Arizona, YAC, 6425 W. 8th St., Yuma, AZ 85364, T.M. Blackmer, G.E. Meyers, and J.S. Schepers, Univ. of Nebraska, USDA, ARS, Lincoln, NE 68583.

Lettuce (*Lactuca Sativa* L.) produced in the low desert typically shows large yield responses to N fertilization. Concern about the potential threat of nitrate-N to ground water prompted the state of Arizona to pass legislation aimed at implementing improved N management practices. Nitrogen management guidelines recommended by the University of Arizona for lettuce suggest a preplant application based on a soil nitrate-N test and subsequent sidedress applications based on plant tissue monitoring. However, growers have some anxiety that close adherence to recommendations resulting from an average plant sample may compromise crop uniformity. Aerial photographs have the potential to detect differences in N status in any portion of the field. This study evaluated digital computer analysis of aerial photographs as a tool for evaluating the N status of lettuce. The digitized photographs appeared to detect deficiencies not apparent to the human eye. There were good correlations ($R^2 0.83$ to 0.99) between Gray-scale ratio and N status, suggesting digital analysis of aerial photographs has potential for diagnosing N deficiencies in lettuce.

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PB 031

ENHANCEMENT OF NUTRIENT UPTAKE IN *LACTUCA SATIVA* BY THIAMIN APPLICATIONS.

D.A. Martens*, Univ. of California, Riverside, Dept. Soil & Environmental Science, Riverside, CA 92521 and C. Sanchez, YAC, Univ. of Arizona, 6425 W. 8th St., Yuma, AZ 85364.

Incorporation of specific vitamins such as thiamin to the rooting media has been reported to stimulate root and shoot growth. Thiamin is involved in the Krebs cycle decarboxylation of pyruvate to citrate as a coenzyme in the pyruvate decarboxylase enzyme complex. Axenic and soil glasshouse studies were conducted to determine the tissue nutrient concentrations (ICP analysis), especially Ca, in response to low application rates of thiamin. In a 50 d axenic "Grand Rapids" lettuce study, thiamin (5 mg mL⁻¹ 0.5 N Hoagland's) stimulated shoot length (25%), root length (23%), Ca (8%), K (14%), and P uptake (18%) compared with control values (no thiamin

added). Soil glasshouse "Grand Rapids" lettuce studies showed that thiamin (6 mg kg⁻¹ soil) stimulated N (72%), Ca (58%), K (12%), and P uptake (11%) compared with control values. Additional glasshouse-soil-thiamin form studies with "Black seeded Simpson" lettuce (20 mg each form kg⁻¹ soil) showed thiamin compounds increased Ca tissue levels from 3 to 10% and organic C content from 5 to 30%. The prospect of using these compounds to reduce tipburn in lettuce is being investigated in follow-up studies.

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PB 034

EVALUATION OF CHLOROPHYLL METER READINGS FOR ASSESSING THE N STATUS OF LETTUCE

M. Wilcox*, C.A. Sanchez, Univ. of Arizona, YAC, 6425 W. 8th St., Yuma, AZ 85364 and T.M. Blackmer, Univ. of Nebraska, Lincoln, NE 68583.

Several studies in the midwestern United States have shown that chlorophyll meter readings (Minolta SPAD 502) are useful in determining the N status of corn (*Zea Mays* L.), and show promise as a tool for the efficient N management of corn. Studies were conducted to evaluate the potential of the 'chlorophyll meter for evaluating N deficiencies in lettuce (*Lactuca sativa* L.). Data for chlorophyll meter readings, midrib nitrate-N, lettuce growth rate, and marketable lettuce yield were collected in five N fertility experiments in 1993 and 1994. Chlorophyll meter readings not only varied among lettuce types (butter, cos, leaf, crisphead), but also among cultivars of the crisphead type. Chlorophyll meter readings were generally poorly correlated to midrib nitrate-N levels and marketable lettuce yield. Lettuce leaves have more color variation than corn leaves, and perhaps this variation in relation to the small sensor size on the SPAD 502 confounded readings. The observation that subtle N deficiencies in lettuce are usually manifested in growth rate reduction rather than abrupt color changes may also limit the usefulness of the chlorophyll meter for lettuce.

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PB 037

POTATO YIELD AND SOIL NITRATE CONCENTRATIONS INFLUENCED BY NITROGEN APPLICATION AND ENVIRONMENTAL CONDITIONS

S. B. Sterrett*, D. V. Midkiff, and C. P. Savage, Jr., Eastern Shore Agricultural Research and Extension Center, Virginia Tech, 33446 Research Drive, Painter, VA 23420
The influence of nitrogen source (commercial vs two slow-release sources), nitrogen rate at planting (56 vs 112 kg/ha) and nitrogen sidedress at early bloom (0, 56 lb N) on potato yield and soil nitrate concentrations was examined in a 3 year field study on a Bojac sandy loam soil. In each year significantly lower yields were recorded for one of the slow-release forms of N, but not the same source each year. Increased N applied at planting increased yield in 1992 and 1993, while sidedress N increased yield only in 1992. Soil nitrate concentrations in 1991 were substantially higher throughout the growing season than in 1992, particularly in the 0-23 cm (surface) layer. Sidedressed nitrogen significantly increased soil nitrate concentration at 0-23, 23-46, and 46-99 cm depths, with the greatest increases recorded in 1991. The rainfall during the growing season in 1991 was 23.5 cm, while in 1992 and 1993 rainfall was 38 and 31 cm, respectively. This study suggests that late N applications can contribute to nitrate movement through the soil profile without consistently improving tuber yield.

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PB 040

PHOSPHORUS FERTILIZER ALTERS DEPTH OF ROOT SYSTEM DEVELOPMENT IN FOUR POTATO CULTIVARS

Darryl D. Warncke and William B. Evans*, Department of Crop and Soil Sciences, Michigan State University, East Lansing, MI 48824-1325.

Phosphorus applications can increase potato yields in Michigan soils with over 400 kg-ha⁻¹ Bray-Kurtz P1 extractable P. Four potato cultivars (Onaway (On), Kennebec (Ke), Russet Norkotah (RN), and Snowden (Sn)) were planted on 7 May 1993 to study P fertilizer effects on root growth and development. Each plot received adequate N & K, and either 0 or 50 kg-ha⁻¹ P. Two minirhizotrons (5 cm i.d.) were set 1.1 m deep at 45° to the soil surface into each plot. P treatment did not influence tuber yield. At 65 days after planting, root counts for On, RN and Sn averaged 72, 44 and 58%, respectively, of those in Ke plots. The P treatment did not significantly influence total root counts within or across cultivars on any of five sampling dates. More visible roots were produced in the first 0.4 m of soil by plants receiving P than by plants not receiving P. Below the first 0.4 m, plants not fertilized with P produced more visible roots than those receiving P.

IRON DEFICIENCY IN POTATO IN THE MEDITERRANEAN REGION AND ITS CONTROL THROUGH RESISTANT GENOTYPES AND NUTRIENT APPLICATION.

Zaiter, H.Z. American University of Beirut, 850 Third Avenue, New York, N.Y., 10022.

Iron-deficiency symptoms are observed on some genotypes of potato (*Solanum tuberosum* L.) grown on high-pH and calcareous soils. seven potato cultivars differing in response to iron deficiency chlorosis (FeDC) were grown on high-pH (8.1), calcareous (38% calcium carbonate equivalent in surface 20 cm) and silty clay soil in the field (Beka'a Valley, Lebanon), to determine the effects of FeDC on tuber yield of cultivars sprayed with Fe. A significant interactions between cultivars and Fe spray treatment were noted for visual FeDC ratings and tuber yield. Even though only slight FeDC was noted on some cultivars receiving no Fe spray, tuber yields were significantly increased when sprayed with Fe. Some cultivars with moderate FeDC ratings did not show a significant increase in yield when sprayed with Fe while other cultivars did. Sprayed cultivars generally produced higher tuber yields than unsprayed ones. Indicating that Fe-deficiency chlorosis in the Mediterranean region may be a serious limitation to potato tuber yield.

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PB 066

EVALUATION OF PREPLANT AND FERTIGATED NITROGEN ON YIELD OF DRIP-IRRIGATED BELL PEPPERS

W.H. Tietjen,* P. Nitzsche and W.P. Cowgill, Jr., Rutgers Cooperative Extension of Warren County, Belvidere, NJ 07823

Environmental concerns about nitrate contamination of groundwater have prompted renewed interest in optimizing fertilizer rates. A field study was initiated to study the influence of preplant and drip fertigation rates of nitrogen on the yield of bell peppers grown on Quakertown (QkB) silt loam soil. Preplant nitrogen rates of 0, 56.7, and 113.5 kg ^{ha} were incorporated into the plots before transplanting. The three fertigation rates (0, 17 and 34 Kg/mulched hectare) were injected through the drip irrigation starting one week after transplanting and repeated at three week intervals.

Proplant nitrogen applications variably influenced early pepper yield, and did not significantly influence total yield. Early pepper yield was not influenced by drip fertigation rate, however, total yield increased as the fertigation rate increased. The dry weather conditions of the 1993 growing season may have influenced the response of pepper yield to the fertilizer treatments. Further studies are required to determine the optimum fertilization program for bell peppers grown under Northern New Jersey's edaphic conditions.

98 POSTER SESSION 14 (Abstr. 659-684) Genetics/RAPD/QTL

TRANSFORMATION OF EASTER LILY VIA PARTICLE BOMBARDMENT

Joyce Van Eck*, Franzine Smith, Ala D. Blowers, and John Sanford, Sanford Scientific, 877 Marshall Rd., Waterloo, NY 13165

Particle bombardment was investigated as a potential transformation method for Easter lily. Bulb scale explants from *Lilium longiflorum* Thunb. 'Nellie White' were used as target material. The *uidA* (or *gusA*) reporter gene for β -glucuronidase (GUS) expression was used in all particle bombardments to assess efficiency of gene delivery. Parameters examined to achieve optimal levels of transient GUS expression included gene promoter, helium pressure (particle velocity), and target distance. The highest level of transient GUS expression (as measured by number of indigo-stained cells/scale explant) was observed with the rice actin 1 (*Act1*) promoter, a helium pressure of 1500 psi, and target distances of 9 to 12 cm. Parameters considered for recovery of stable transformants included the choice of selective agent (phosphinothricin or hygromycin) and their respective selectable resistance genes (phosphinothricin acetyltransferase and hygromycin phosphotransferase), and preculture time of scale explants prior to bombardment. Polymerase chain reaction analysis will be used to screen putative stable transformants, and from this data it will be determined which parameters yielded the highest transformation rates.

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IDENTIFICATION OF GENETIC VARIABILITY AMONG SPECIES AND CULTIVARS OF PENSTEMON USING RANDOM AMPLIFIED POLYMORPHIC DNA (RAPDs)

Guenhwa Jung*, Dale T. Lindmen, and Dermot P. Coyne: Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724

Eight species and 57 selections/cultivars of *Penstemon* were compared for genetic variability using Random Amplified Polymorphic DNAs (RAPDs). The RAPD technique was used to help understand the genetic relationships in species and cultivars in the genus *Penstemon*. Ten RAPD primers (from Operon) were screened to identify polymorphisms among these eight species and 57 selections. More than 100 RAPD polymorphic bands were obtained. A principle component analysis was used to study genetic relationships. Variation among species was greater than variation among selections/cultivars within species. RAPD markers distinguished differences between most cultivars tested. DNA fingerprints generated by RAPDs should be useful to distinguish cultivars of *Penstemon*, as well as to assist in determining genetic relationships between species.

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PB 075

POLYMORPHIC DNA PROFILES AID IN DISTINGUISHING *PETUNIA* SPECIES

Teresa A. Cerny* and Terri W. Starman, Department of Ornamental Horticulture and Landscape Design, Institute of Agriculture, University of Tennessee, Knoxville, TN. 37901

Our overall objective was to use DNA Amplification Fingerprinting (DAF) to determine the relationships between *Petunia X hybrida* and four wild *petunia* species, *P. axillaris*, *P. inflata*, *P. parodii*, and *P. violacea*. This research was to optimize the DAF amplification reaction for petunias, check for variability in the fingerprints among different seedlings of the same species and screen primers to be used for identifying polymorphisms between cultivars of *P. X hybrida* and the four wild species. Optimization of the DAF procedure was accomplished by varying concentrations of DNA template (0 - 10 ng), MgCl₂ (0 - 10 mM), and primers (0 - 30 μ M). Optimum concentrations were found to be 1.0 ng DNA template and 2.0 mM MgCl₂. Clearly resolved banding patterns were produced using primer concentrations from 3.0 μ M to 30 μ M. When separate seedlings of each wild species from the same seed source were fingerprinted, profiles were consistent. Seeds from other sources are presently being collected to investigate variation between sources. Twenty-five heptamer and octamer primers varying in GC content were screened and ten produced clear banding patterns for the *Petunia* species. These primers have produced polymorphic profiles between the pink-flowering species and the white-flowering species. Several primers have shown distinct polymorphisms between *P. axillaris* and *P. parodii*, the two white-flowering species, which have very similar morphological traits. Similarities in the banding patterns have been found between *P. X hybrida* and these wild species.

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PB 078

STABLE TRANSFORMATION OF *GLADIOLUS* PLANTS

Kathryn Kamo*, Alan Blowers, Franzine Smith, Joyce Van Eck, Floral & Nursery Plants Research, USDA, Beltsville, MD 20705, *Sanford Scientific, 877 Marshall Rd., Waterloo, NY 13165

Over one hundred *Gladiolus* plants of the commercially important cultivars 'Jenny Lee' and 'Peter Pears' have been stably transformed following particle bombardment on regenerable callus, suspension cells, or cormel slices. The phosphinothricin acetyltransferase gene which confers phosphinothricin resistance was cotransformed with either antiviral genes or the *uidA* reporter gene coding for β -glucuronidase expression. Transformed plants were regenerated following selection on concentrations of phosphinothricin which varied with the type of tissue used for bombardment. Integration of foreign DNA was confirmed by polymerase chain reaction and gene expression.

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IDENTIFICATION OF POINSETTIA CULTIVARS USING RAPD MARKERS

Jing-Tian Ling*, Roger Sauve and Nick Gawel, Cooperative Agricultural Research Program, Tennessee State University, Nashville, TN 37209-1 562

The development of scoreable genetic markers in poinsettia will be valuable for cultivar identification and for use in patent protection. In this study, polymerase chain reaction (PCR) and randomly amplified polymorphic DNA (RAPD) techniques were investigated for their feasibility in the identification of poinsettia cultivars. DNA was extracted from leaf tissues using the CTAB method. Thirty-six out of 39 (92.4%) primers amplified poinsettia DNA. The size of the amplified DNA fragments ranged from 140 to

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2,000 base pairs. On average, 5.4 bands (range 1 - 13) were obtained per primer. A total of 195 bands were obtained; 49 (25.1%) bands were polymorphic in the 9 tested poinsettia cultivars. All tested cultivars could be discriminated with the banding profiles generated from 2 primers. RAPD markers provide a consistently reliable and efficient technique for the identification of poinsettia cultivar.

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AGROBACTERIUM INFECTION OF WHITE ASH (FRAXINUS AMERICANA L.)

Sharon A. Bates*, John E. Preece, and John H. Yopp, Departments of Plant and Soil Science and Plant Biology, Southern Illinois University, Carbondale, IL 62901-4415

Both greenhouse-grown white ash plants derived from tissue culture and rooted microshoots in high humidity trays were inoculated with 11 tumor-inducing *Agrobacterium* strains. Eight strains stimulated mutative gall formation. Plants inoculated with strain A281 exhibited a higher frequency of callus formation (greenhouse-22.2%; microshoots-18.8%) than other strains at the site of the wound. Therefore, strain A281 was used to inoculate seed and seedling explants in vitro. Explants were placed on MS medium containing no plant growth regulators and inoculated at 0, 3, 5, 7, or 10 days after initiation. Plants inoculated at 10 days showed a higher frequency of callus formation (16.4%) than with earlier inoculations. Also, rewounding of the explant at inoculation resulted in a higher frequency of callus formation (11.3%) compared to not rewounding the explant (3.9%).

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DNA POLYMORPHISM IN SILVER MAPLE (ACER SACCHARINUM L.).

A. Virginia Freire*, John E. Preece, David A. Lightfoot, Department of Plant and Soil Science, Southern Illinois University, Carbondale, IL 62901-4415.

Silver maple has great potential as a biomass feedstock. We selected 21 elite silver maple clones representing 7 provenances located on east to west and north to south transects across the natural area of distribution. In addition five different red maples including one commercial cultivar as well as four interspecific hybrids between red and silver maple were compared to the silver maples. DNA was extracted using a modification of the CTAB technique (Murray and Thompson, 1980). Polymerase chain reaction was used with random primers from the OPF series (1-20) and primers used by Krah et al. (1993). Polymorphism was detected at high frequency. Greater polymorphism was observed between species than within species. However, we have observed DNA concentration dependent polymorphism. RAPD technology has potential for determination of genetic relationship among silver maple clones.

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RANDOM AMPLIFIED POLYMORPHIC DNA MARKERS ARE INADEQUATE FOR FINGERPRINTING GRAPE ROOTSTOCKS

Alan T. Bakalinsky*, Hong Xu, Diane J. Wilson, and S. Arulsekhar, Department of Food Science and Technology, Wiegand Hall, Oregon State University, Corvallis, OR 97331-6602

A total of eight random amplified polymorphic DNA (RAPD) markers were generated in a screen of 77 primers of 10-base length and were detected reproducibly among nine different grape (*Vitis*) rootstocks. Occasional failed amplifications could not be explained rationally nor easily corrected by systematic replacement of individual reaction components. In an effort to improve their reliability, the RAPD markers were cloned, their termini sequenced, and new sequence-specific primer pairs were synthesized based on addition of 10 to 14 bases to the 3' termini of the original 10-mers. Six pairs of the new primers were evaluated at their optimal and higher-than-optimal annealing temperatures. One primer pair amplified a product the same size as the original RAPD marker in all rootstocks, resulting in loss of polymorphism. Post-amplification digestion with 7 different restriction endonucleases failed to reveal restriction site differences. Three primer pairs amplified an unexpected length variant in some accessions. Two other pairs of primers amplified a number of unexpected bands. Better approaches for exploiting the sequence differences that account for the RAPD phenomenon will be discussed.

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IDENTIFICATION OF LINKED RAPD MARKERS TO IMPORTANT LOCI IN PEACH AND ALMOND

Marilyn L. Warburton* and F. A. Bliss Department of Pomology, University of California at Davis, Davis, CA 95616

Genetic linkage maps for many organisms are being produced using molecular markers. The utility of these maps depends on the ability to place genes of known, important effects on the map. It is often useful to saturate the chromosome around these loci with many linked molecular markers. This study used Bulk Segregant Analysis and Random Amplified Polymorphic DNA to identify linked markers to loci in peach, *Prunus persica* L. Batch and almond *Prunus dulcis* Mill populations. Linkages to isozyme loci were first sought to test the suitability of this technique to long-lived perennials. Several RAPD markers were found to be linked to three isozyme loci in a segregating F3 population from a peach x almond cross. RAPD markers have also been identified which are linked to the yellow-flesh locus of peach in a heterozygous peach population. Thus, this method has proven useful for identifying molecular marker linkages to important loci in peach and almond. These RAPDs may now be placed on a linkage map generated in our lab using a peach/almond hybrid population which will allow these loci to be studied and manipulated more easily in a breeding program.

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Genetic Linkage Mapping in *Prunus*

M.R. Foolad, S. Arulsekhar and F. Bliss*, Department of Pomology, University of California, Davis CA 95616

A genetic linkage map of *Prunus* has been constructed using an interspecific F2 population generated from self-pollinating a single F1 plant of a cross between a dwarf peach selection (54P455) and an almond cultivar (*Padre*). This map consists of approximately 80 markers including 10 isozymes, 12 plum genomic, 19 almond genomic and 40 peach mesocarp specific cDNA clones. The backbone map will be used for identifying the genomic locations and characterization of genes governing important economic traits in the genus *Prunus*. Of particular interests are those genes associated with fruit ripening and mesocarp development in peach and almond.

669 PB 119
VARIABILITY AND INHERITANCE OF RAPD MARKERS IN JAPANESE-TYPE PLUMS

Unaraj Boonprakob* and David H. Byrne, Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

Six controlled crosses of cultivated and advanced selection Japanese-type plums adapted to southeast and southwest regions of the United States were made in 1990 and 1991. Over 800 seedlings from these crosses along with open pollinated seedlings of the parents were established in Suiting nurseries. The long range objective of this study is to determine linkage relationships between RAPD markers and commercially important traits (soluble solid, resistance to bacterial leaf spot, chilling requirement, fruit development period). The first step in the projects to characterize RAPD genotypes in the progenies. Eighty oligodecamers have been screened and 57 yielded successful reactions with an average of two to three bands per primer. The variability and inheritance of the RAPD markers in these plum populations will be described.

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PHYLOGENETIC RELATIONSHIPS OF CULTIVATED *PRUNUS* SPECIES FROM AN ANALYSIS OF HYPERVARIABLE CHLOROPLAST DNA

Maria L. Badenes and Dan E. Parfitt*, Instituto Valenciano de Investigaciones Agrarias, Apartado Oficial, 46113 Moncada (Valencia) Spain, Department of Pomology, University of California, Davis CA 95616

Chloroplast DNA (cpDNA) mutations in 7 cultivated *Prunus* species were compared to establish the phylogenetic relationship among them. Mutations were detected in 3.2 kb and 1.5 kb regions of hypervariable cpDNA, amplified and cut with 21 and 10 restriction endonucleases, respectively, to reveal polymorphisms. Parsimony and cluster analyses were performed. Two groups of species, *P. persica* and *P. dulcis* and *P. domestica* and *P. salicina* were completely monophyletic. The subgenus

Cerasus was the most recently derived, while the subgenus *Amygdalus* was the most ancestral and somewhat separate from the rest of *Prunus*. The results also suggest that the rate of mutation in the *Cerasus* chloroplast genome is significantly greater than for the other subgenera sampled.

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GENETIC LINKAGE MAPPING IN PEACH

S. Rajapakse*¹, L. E. Belthoff², R. Scorza³, R. E. Ballard⁴, W.V. Baird⁵, R. Monet⁶, and A. G. Abbott⁷. ¹Department of Biological Sciences, Clemson University, Clemson, SC 29634, ²Department of Horticulture, Clemson University, Clemson, SC 29634, ³Appalachian Fruit Research Station, Agricultural Research Service, U.S. Department of Agriculture, Kearneysville, WV 25430, ⁴INRA Centres de Recherches de Bordeaux, 33883 Villenave D'Omon Cedex, France

We have constructed a genetic linkage map of peach consisting of RFLP, RAPD, and morphological markers, based on 78 F₂ individuals derived from the self-fertilization of four F₁ individuals originating from a cross between 'New Jersey Pillar' and KV 77119. This progeny set was chosen because parental genotypes exhibit variation in canopy shape, fruit flesh color, and flower petal color, size, and number. The segregation of 81 markers comprised of RFLP, RAPD and morphological loci was analyzed. Low copy genomic and cDNA probes were used in the RFLP analysis. The current genetic map for the WV family contains 57 markers assigned to 9 linkage groups, which cover 520 cM of the peach nuclear genome. The average distance between two adjacent markers was 9 cM. Linkage was detected between Pillar (*Pi*) and double flowers (*DI*). RFLP markers loosely linked to *Pi*, flesh color (*Y*), and white flower (*W*) loci were found. Twenty-four markers remain unassigned.

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EXAMINATION OF QUANTITATIVE TRAIT LOCI IN APPLE (MALUS X DOMESTICA) USING MOLECULAR MARKERS

Patrick J. Conner*, Susan K. Brown and Norman F. Weeden, Department of Horticultural Sciences, Cornell University, New York State Agricultural Experiment Station, Geneva NY 14456

Molecular markers (isozyme and DNA) have been used to map apple and have helped to elucidate the inheritance of some morphological traits. In this project random amplified polymorphic DNA (RAPD) and isozyme markers were used to create maps for 'Wijcik McIntosh', a columnar (reduced branching) sport of 'McIntosh' and NY 75441-67, an advanced selection from the multiple disease resistance breeding program. NY 75441-67 is resistant to scab and source of resistance from *M. floribunda* and resistant to cedar apple rust. 'Wijcik McIntosh' is being used in the breeding program as a source of the dominant gene, *Co*, for reduced branching, but there is also interest in this genotype because of the tremendous variation in plant form observed in progenies segregating for columnar habit. Some of these form variants may be of greater commercial interest than the parental material. Morphological traits examined in this progeny included plant height, stem diameter, suckering, branching habit, spur production, and internode length. The usefulness of molecular markers to pre-select for components of plant form is being examined. Molecular markers promise to aid our understanding and manipulation of quantitative morphological traits.

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MOLECULAR MARKERS FOR FRUIT COLOR IN APPLE (MALUS X DOMESTICA)

Frank Cheng*, Norman Weeden, and Susan Brown, Department of Horticultural Sciences, Cornell University, New York State Agricultural Experiment Station, Geneva NY 14456

The ability to pre-screen apple populations for fruit color at an early seedling stage would be advantageous. In progeny of the cross 'Rome Beauty' x 'White Angel' red/yellow color variation was found to be highly correlated with the genotype at *Idh-2*, an isozyme locus that was heterozygous in both parents. We postulate that the red/yellow color variation was produced by a single gene linked to *I&-2* and also heterozygous in both parents. This population was also screened with over 400 primers to detect randomly amplified polymorphic (RAPD) markers for fruit color. DNA extraction procedures were developed for bark, and DNA was extracted from bark samples and leaves. Red and yellow fruited individuals were examined in bulk. Several markers have been found that are linked to red color. A high density map is being constructed in this region. These markers are being examined in other crosses segregating for fruit color. The application of these markers will be discussed in relation to the inheritance and manipulation of fruit color.

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DEVELOPMENT OF AN RFLP MAP FOR WALNUT

Robert G. Fjellstrom* and Dan E. Parfitt, NFSPRC, USDA, 3450 Campus Way, Corvallis OR 97331, Department of Pomology, University of California, Davis CA 95616

32 cloned probes from a walnut (*Juglans* sp.) PstI random genomic library were used to develop a linkage map for walnut. Low copy number walnut random genomic DNA probes were constructed and hybridized to restriction endonuclease digested DNA from parent walnut trees from a backcross of (*J. hindsii* x *J. regia*) with *J. regia* to identify parental polymorphism. 63 backcross progeny were analyzed to determine the inheritance and linkage of 48 RFLP loci. 66% of the probes detected duplicated, but unlinked loci. 42 of the RFLP loci could be placed on 12 linkage groups. The other 6 loci could not be placed on common linkage groups. (Theoretical maximum number of linkage groups is 16.) A Poisson probability method for estimating genome size was utilized to calculate the approximate walnut genome length as 1660 cm and to estimate that 138 markers would be needed to cover 95% the walnut genome within 20 cM of each marker.

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GENETIC RELATIONSHIPS OF JUGLANS REGIA L. CULTIVARS DETERMINED FROM RFLP ANALYSIS

Robert G. Fjellstrom*, Dan E. Parfitt, and Gale H. McGranahan, NFSPRC, USDA, 3450 Campus Way, Corvallis OR 97331, Department of Pomology, University of California, Davis CA 95616

RFLP markers were used to study genetic diversity among California walnut (*Juglans regia* L.) cultivars and germplasm collected worldwide. 16 of 21 RFLP markers were polymorphic in the 48 walnut accessions tested. Seven RFLP markers permitted unique identification of all walnut cultivars. All genotypes were heterozygous at approximately 20% of the loci for both California and worldwide germplasm. California walnut germplasm contained 65% of the worldwide allelic diversity. Cluster analysis of genetic distance between accessions and principal component analysis of allelic genotypes showed two major groups of walnut domestication. California germplasm was associated with germplasm from France, Central Europe, and Iran, and had less genotypic similarity with germplasm from Nepal, China, Korea, and Japan.

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IDENTIFICATION AND CLASSIFICATION OF PISTACHIO (*Pistacia vera* L.) CULTIVARS WITH RAPD MARKERS

J.I. Hormaza, L. Dollo, V.S. Polito, Department of Pomology, University of California, Davis, CA 95616

The Random Amplified Polymorphic DNA (RAPD) technique was used to characterize 15 cultivars of pistachio (*Pistacia vera* L.). A total of 37 polymorphic markers were considered in this study. Each cultivar exhibited a unique molecular phenotype and, as a consequence, can be uniquely fingerprinted. A similarity and cluster analysis based on the amplified fragments produced two distinct groups which are consistent with the known geographical origin of the cultivars. Our results suggest that RAPD analysis can provide a new alternative for cultivar identification and classification of pistachio.

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IDENTIFICATION OF OLIVE (*Olea europaea* L.) CULTIVARS WITH RAPD MARKERS

A. Fabbri, J.I. Hormaza, V.S. Polito, Department of Pomology, University of California, Davis, CA 95616

We have been screening olive (*Olea europaea* L.) cultivars using the Random Amplified Polymorphic DNA (RAPD) technique. We examined 23 olive cultivars selected to represent the important olive-growing regions of the world. These include oil and table olive cultivars originating from throughout the Mediterranean area. A high degree of polymorphisms is evident in the olive germplasm we examined. Early results indicate that polymorphisms that exist within the species are sufficient to enable efficient development of RAPD markers for distinguishing olive cultivars.

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RAPD GENETIC MARKERS FOR CHARACTERIZATION OF MUSA GENETIC RESOURCES

R.L. Jarret and K.V. Bhat, USDA/ARS, Plant Genetic Resources Unit, 1109 Experiment Street, Griffin, GA 30223; NBPGR, Pusa campus, New Delhi 110012, India.

Fifty-seven accessions of *Musa* including cultivated clones of 6 genomic groups (AA, AB, AAA, AAB, ABB, ABBB), *M. balbisiana* (BB), *M. acuminata* ssp. *banksii* (AA), *M. acuminata* ssp. *malaccensis* (AA) and *M. velutina* were examined for random amplified polymorphic DNA (RAPD) genetic markers using PCR with sixty 10-mer random primers. Forty-nine of 60 tested primers gave reproducible DNA amplification patterns. The number of bands resolved per amplification was primer dependent and varied from 1 to a maximum of 24. The size range of the amplification products also differed with the select primer sequence/genotype and ranged from 0.29 to 3.0 kb. RAPD data were used to generate Jaccard's similarity coefficients which were analyzed phenetically. Phenetic analysis separated clones into distinct groupings that were in agreement with clusterings revealed when data were subsequently analyzed by principal coordinate analysis (PCO). In both the phenetic and the PCO analyses, previously unclassified cultivars grouped with cultivars previously classified for their genomic group based on morphological keys. The implications of RAPD analysis for *Musa* germplasm classification, clonal identification, and management are discussed.

USE OF RAPDS IN ANNONA SPECIES

Catherine M. Ronning*, Raymond J. Schnell¹, and Shmuel Gazit², USDA-ARS Subtropical Horticulture Research Station, 13601 Old Cutler Rd., Miami, FL, 33158, and ²the Volcani Institute, P.O. Box 6, Bet Dagan 50250, Israel

The native American genus *Annona* contains many species that are cultivated in the tropics and subtropics for their edible fruit, including the custard apple (*A. reticulata*), soursop (*A. muricata*), cherimoya (*A. cherimola*), sugar apple (*A. squamosa*), and the interspecific hybrid, *Atemoya*. Random Amplified Polymorphic DNA (KAPD) analysis of the *A. cherimola* cultivars 'Jete' and 'Campa', *A. squamosa* 'Lessard', and the *Atemoya* cultivars 'Ubranzitzki', 'Mallali', and 'Kaspi' resulted in very distinctive patterns, indicating that RAPD markers are an easy, efficient method of fingerprinting *Annona* species. Thirteen of 15 primers gave repeatable, polymorphic patterns. An F1 population of 'Jete' x 'Lessard' as well as selfed populations of 'Jete' and of 'Lessard' were analyzed to determine the inheritance of the KAPD banding patterns. The results indicate that KAPD analysis can be used in genetic and phylogenetic studies of *Annona* species.

INHERITANCE OF KAPD PATTERNS IN THEOBROMA CACAO

Catherine M. Ronning* and Raymond J. Schneg, USDA-AKS Subtropical Horticulture Research Station, 13601 Old Cutler Rd., Miami, FL 33158

While Random Amplified Polymorphic DNA (KAPD) has been used successfully in genetic analysis of several crop plants, the method poses difficulties with a heterozygous species such as *Theobroma cacao* due to the dominant phenotypic expression of bands. A backcross family of the cultivars 'Catoneo' and 'Pound 12' was analyzed to determine the efficacy of this technique in analyzing cacao populations. A primary screen of the parents and F1 was conducted with 180 KAPD primers; of these, 39.5% either did not amplify or did so poorly or irreproducibly, while 60.5% amplified well. Phenotypes produced by 42 primers represented possible test crosses, which can be used in linkage mapping. Genomic DNA from 50 individuals of the backcross population were then amplified with these 42 primers, which in most cases resulted in 1:1 segregation of bands. Preliminary experiments show that the Stoffel fragment of Taq DNA polymerase may provide additional markers. These results indicate that it should be possible to use RAPD bands as molecular markers to study the cacao genome.

MOLECULAR CHARACTERIZATION OF A cDNA THAT ENCODES 5-AMINOLEVULINIC ACID DEHYDRATASE IN TOMATO

Gary F. Polkin*, David J. Hannapel, and Richard J. Gladon, Department of Horticulture, Iowa State University, Ames, IA 50011-1100

Tomato fruit ripening is characterized by a decrease in chlorophyll content and an increase in lycopene synthesis. We are interested in the role of chlorophyll metabolism as it relates to tomato fruit ripening. 5-Aminolevulinic acid dehydratase (ALAD) is the first committed enzyme in the chlorophyll biosynthetic pathway, and it catalyzes the conversion of two 5-aminolevulinic acid molecules into porphobilinogen. We have isolated a full-length tomato ALAD cDNA clone from a tomato fruit library. Sequence analysis showed that this tomato ALAD was highly

homologous to ALAD found in spinach and pea, and the analysis predicted a protein of 46.8 kDa. Southern analysis indicated that 1 to 3 copies of the ALAD gene are present in the tomato genome. Northern analysis suggested that the gene is expressed constitutively throughout tomato fruit development. Currently, we are subcloning the fragment into an *E. coli* expression vector in order to obtain protein for antibody production for Western analysis.

NICOTIANA FIXATION FOR IMMUNO-LOCALIZATION OF IPTASE

Greg S. Rogers* and John Frett, Plant and Soil Science Department, University of Delaware, 149 Townsend Hall, Newark, DE 19711

A problem in immunocytochemistry is obtaining acceptable fixation of tissue while retaining antigenicity. Two concentrations (1% and 2.5%) of glutaraldehyde, with and without secondary fixation in 1% Osmium Tetroxide (OsO_4) and varying fixation times were used.

Fixation in 1% glutaraldehyde for 3 h was adequate to preserve the tissue. Some loss of fine structure was visible under an electron microscope. A solution of 2.5% glutaraldehyde was more effective in preserving fine structure. At 2 h fixation the tissue was well preserved and only slight loss of fine detail was observed. A longer fixation results in better ultrastructural preservation, but can cause loss of antigenicity.

OsO_4 fixes lipids and acts as an electron dense stain. OsO_4 has a negative effect on antigenicity. The use of OsO_4 had little effect upon the preservation of ultrastructural detail and did not improve staining; therefore, it was omitted in later fixations. Based on this experimental evidence, initial localization experiments will utilize tissue fixed in 1% glutaraldehyde for 3 h.

IDENTIFICATION OF MOLECULAR MARKERS LINKED TO LOW-TEMPERATURE RESPONSES

Rita A. Teutonico, Jiwan P. Palta and Tom C. Osborn

Depts. of Agron. and Hort., Univ. of Wisc.-Madison, 1575 Linden Dr., Madison, WI 53706

Identification of the genes involved in freezing tolerance in oilseed *Brassica* could lead to genetic improvement of winter survival of this crop and other species, as well as provide greater understanding of the basis of cold stress tolerance in plants. We developed a genetic linkage map for *B. rapa* using restriction fragment length polymorphisms (RFLPs) and identified molecular markers which are linked to genes controlling vernalization requirement and freezing tolerance. We mapped the location of a group of cold-regulated ('cor') genes from *Arabidopsis thaliana* in this population and determined their association with freezing tolerance and vernalization requirement. We developed genetically fixed, recombinant inbred lines of *B. rapa* to assay the physiological processes involved in these cold responses. Specifically, we measured the differences in lipid composition of the plasma membranes of acclimated and nonacclimated plants of a subset of this population. We will determine if the genes involved in the physiological responses to cold temperature are also associated with the acquisition of freezing tolerance.

GERMINATION AND SEEDLING GROWTH OF CUCUMBERS IN IMMATURE BIOSOLIDS-YARD TRIMMING COMPOST

Nancy E. Roe* and Peter J. Stoffella University of Florida, Agricultural Research and Education Center, P.O. Box 248, Ft. Pierce, FL, 34954

Rapid production of compost often results in crop damage by phytotoxic compounds or high C/N ratios in immature (uncured) compost. The influence of immature biosolids-yard trimmings compost on germination and growth of cucumber (*Cucumis sativus* L.) was evaluated. Germination percentages of cucumbers seeded in equal parts (v/v) of compost and vermiculite were similar to those in vermiculite. When screened compost was placed in flats and compared with flats of potting mix or sandy field soil, germination percentages were 98, 96, and 89 for mix, sand, and compost respectively. Germination in compost-amended field plots was higher than in soil when cucumbers were planted 1, 2 or 10 weeks after compost application, but similar in 3 and 5 week plantings. Use of this immature compost increased, decreased, or did not affect cucumber seed germination, depending on media and growing conditions.

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Water Stress and Utilization

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A SIMPLE COMPUTER PROGRAM FOR UPDATING WATER BUDGETS FOR IRRIGATED VEGETABLES

Eric H. Simonne and Joseph M. Kemble*, Dept. of Horticulture, Auburn University, AL 36849-5630 and Doyle A. Smittle, Coastal Plain Experiment Station, Horticulture Dept., Tifton GA 31793

A TurboPascal computer program was developed to calculate daily water budgets and schedule irrigations. Daily water use (d_i) is calculated as pan evaporation (E_p) times a crop factor (CF), where i is crop age. The water balance uses a dynamic rooting depth, the soil water holding capacity (SWC) and rainfall data (R). d_i is added to the cumulative water use (D_i) and R is subtracted from D_i . An irrigation in the amount of D_i is recommended when D_i approximates allowable water use. The program can be adapted to most crop and soil types, and can be used for on-time irrigation scheduling or for simulating water application using past or projected weather data. This program should increase the acceptance of modern scheduling irrigation techniques by farmers and consultants. Additionally, this program may have application in an overall water management programs for farms, watersheds or other areas where water management is required.

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RESEARCH AND DEVELOPMENT OF A MINIATURE PAN EVAPORIMETER FOR GAUGING THE DIFFERENCE BETWEEN EVAPOTRANSPIRATION AND EFFECTIVE RAINFALL

Christopher L. Browne* and Thomas W. Cook, Moisture Dynamics, Inc., P.O. Box 2066, Corvallis, OR 97339, and Oregon State University Horticulture Dept. #4017 ALS, Corvallis, OR 97331

Knowledge of the current irrigation requirement of well-watered grass provides the basis for efficient scheduling of turf and landscape irrigation. A portable, miniature pan evaporimeter has been developed to conveniently provide this information for localized micro-climates. The underlying equation for the instrument is: $IR_{net} = (K_{pan} \cdot E_{pan} - K_{pan} \cdot R)$ where IR_{net} is the net irrigation requirement of healthy, non-stressed grass; K_{pan} is the pan coefficient for the instrument; E_{pan} is accumulative pan evaporation; $K_{pan} \cdot E_{pan}$ is "reference evapotranspiration"; and $K_{pan} \cdot R$ is a measure of effective rainfall received. This equation was established using turfgrass sites located throughout the Pacific Northwest over a 3-year period. The sites were in proximity to U.S. Class "A" pan evaporimeters, and were automatically irrigated using moisture sensors. Tests of the miniature evaporimeter against automated meteorological stations have determined the factors that influence its pan coefficient, and therefore its ultimate design.

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POTATO RESPONSE TO DEFICIT IRRIGATION

Clint C. Shock*, Erik B. G. Feibert and Monty Saunders, Malheur Experiment Station, 595 Onion Ave., Ontario, OR, 97914.

Seven potato cultivars were grown in an adequately irrigated check (100% of crop evapotranspiration replaced at -60 kPa) and three deficit irrigation regimes in order to evaluate varietal response to water stress and to evaluate nitrate leaching below the crop root zone in relation to the irrigation management. Potatoes were grown with sprinkler irrigation on silt loam in 1982 and 1993. Water stress treatments were achieved by partial or complete crop evapotranspiration replacement when soil water potential reached -60 or -80 kPa. In 1992, over all varieties, tuber yield and grade were significantly reduced by the two higher levels of water stress. In 1993, a relatively cool year, yield was reduced by water stress, but grade was not. Tuber internal quality was affected more by variety than by deficit irrigation both years. A comparison of pre-plant and post-harvest soil nitrate and ammonium shows that a small amount of nitrate moved from the top two feet of soil to the third and fourth foot in the check plots. Soil nitrogen accounting for the season showed large surpluses, indicating the importance of natural sources of available nitrogen.

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WATER STRESS REDUCES ASPARAGUS GROWTH

Dan Drost*, Department of Plants, Soils, and Biometeorology, Utah State University, Logan, UT 84322-4820

In 1992, a long term study was initiated to determine water use of asparagus and to assess water stress effects on asparagus growth. Asparagus (Syn 4-56) crowns were planted and maintained at soil moisture levels near field capacity during the first year. In 1993, irrigation treatments based on 60, 40, and 0 percent of evapotranspiration (ET) were applied to asparagus during the fern growing period (mid-June to October). Soil moisture, shoot and root growth, and fern water potentials were measured throughout the year. Prior to the irrigation treatments, asparagus had 39 buds per plant with a shoot and root fresh weight of 573 and 270 grams, respectively. Soil moisture in the root zone (0 to 60 cm) approached the permanent wilting point in the 40% and 0% of ET treatments by mid-August. A decrease in irrigation rate from 80 to 0% of ET had no effect on fern fresh weight at the end of the growing season. However, as irrigation rate decreased from 80 to 0% of ET, root fresh weight (586, 533, 415 grams) and bud number (78, 59, 53) decreased linearly. These results suggest yield and growth may be reduced in 1994.

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PB 239

SOIL WATER POTENTIAL IRRIGATION CRITERIA FOR ONION PRODUCTION

Erik B. G. Feibert*, Clint C. Shock and Monty Saunders, Malheur Experiment Station, 595 Onion Ave., Ontario, OR 97914

Onions were grown with different soil water potentials as irrigation criteria to determine the soil water potential at which optimum onion yield and quality occurs. Furrow irrigation treatments in 1992 and 1993 consisted of six soil water potential thresholds (-12.5 to -100 kPa). Soil water potential in the first foot of soil was measured by granular matrix sensors (Watermark Model 200SS, Irrrometer Co., Riverside, CA) that had been previously calibrated to tensiometers on the same silt loam series. Both years, yield and market grade based on bulb size (more jumbo and colossal onions) increased with wetter treatments. In 1993, a relatively cool year, onion grade peaked at -37.5 kPa due to a significant increase in rot during storage following the wetter treatments. These results suggest the importance of using moisture criteria to schedule irrigations for onions.

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PB 262

EFFECT OF IRRIGATION ON THE YIELD AND YIELD COMPONENTS OF TOMATO

Daniel Smeal*, E.J. Gregory, R.N. Arnold and J. Tomko, New Mexico State University, Agricultural Science Center, P.O. Box 1018, Farmington, NM 87499-1018.

A single sprinkler line-source was used to provide irrigation treatments to three tomato (*Lycopersicon esculentum*) varieties ('Baja', 'Rowpac', and 'Roza') during 1988 and 1989 in northwestern New Mexico. In both years, marketable fruit yield (Y) of all varieties increased linearly with increased irrigation (I). However, the regression coefficients describing the Y vs. I relationship differed with variety and year. In 1989, 'Rowpac' Y ranged from 40.3 to 114.2 Mg ha⁻¹ at levels of 31.5 and 62.5 cm, respectively. Yields of 'Baja' and 'Roza', while similar to those of 'Rowpac' at low I levels, were 59% and 71% of 'Rowpac' Y, respectively, at the highest level of irrigation. At any given I level, Y was lower in 1988 than in 1989. While average weight per fruit (wt/fruit) and number of fruit per plant (no/plant) increased with increasing I level in all varieties, increased Y in 'Rowpac' had a higher positive correlation with no/plant (40 to 90) than with wt/fruit (85 to 120 g). Increasing Y in 'Baja' on the other hand, correlated much better with increased wt/plant (100 to 195 g) than no/plant (20 to 45).

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DRIP IRRIGATION AND FERTIGATION MANAGEMENT CAN MINIMIZE NITRATE LEACHING LOSSES

T.K. Hartz, Department of Vegetable Crops, University of California, Davis, CA 95616

Trials were conducted under California field conditions examining the impact of drip irrigation and nitrogen fertigation regime on in-season NO₃-N leaching losses. Six field studies were conducted, 4 on tomato and 2 on pepper. Seasonal fertigation ranged from 0-440 kg N/ha; irrigation

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was applied 3X per week, with leaching fractions of 10-25% of applied water. NO₃-N leaching losses were estimated both by suction lysimetry and the use of buried anion resin traps. A similar pattern was seen in all trials. From transplant establishment until early fruit set soil solution at 0.8 m had relatively high NO₃-N concentration (>30 mg/liter), which declined as the season progressed; in the month before harvest soil solution NO₃-N at 0.8 m was consistently below 10 mg/liter (tomato) and 15 mg/liter (pepper) in appropriately fertilized plots. Seasonal NO₃-N leaching estimates were generally below 25 kg/ha (tomato) and 35 kg/ha (pepper), with only modest differences among fertigation regimes. These results suggest that well managed drip irrigation can minimize in-season NO₃-N leaching.

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'HASS' AVOCADO RESPONSE TO DIFFERENTIAL IRRIGATION TREATMENTS. D. E. Stottlemeyer*, M. L. Arpaia, J. L. Meyer, G. W. Witney, G. S. Bender, Botany and Plant Sciences Dept. Univ. of CA, Riverside, CA 92521.

The influence of three irrigation treatments on flowering, yield, tree growth, root distribution, and leaf analysis of mature 'Hass' avocado (*Persea americana* Mill.) was investigated over a six year period (1987-1992). Three irrigation treatments; 60, 80, and 100% of evapotranspiration (ETc) were applied using low-volume spray emitters. The differential irrigation treatments were maintained year round. Irrigation treatments did not affect the timing or intensity of bloom. Yield data from years 2-6 show a significant irrigation effect on cumulative weight and total number of fruit per tree. Trees receiving 100% ETc had higher yield/tree. This increased yield was due both to increased fruit numbers and individual fruit weight per tree. Tree growth was also significantly impacted by the irrigation treatments. Trees receiving 100% ETc exhibited the greatest amount of vegetative growth over the study. Yield efficiency (Kg fruit/m³ canopy) was not influenced by irrigation treatment. Irrigation treatment did not significantly influence nutrient analysis taken in the fall of each year.

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ROOT DISTRIBUTION OF MATURE ORANGE TREES FOLLOWING CONVERSION FROM FLOOD TO PRESSURIZED IRRIGATION

G. C. Wright,* R. L. Roth and B. R. Gardner, Yuma Mesa Agricultural Center, University of Arizona, Route 1, Box 40M, Somerton, AZ 85350

Mature 'Campbell Nuccella Valencia' trees were converted from border flood irrigation to four pressurized irrigation systems. A border flood irrigation treatment was included as a control. Four years later, roots were collected from 62 holes (10 cm diameter x 120 cm) on a 60 cm grid on one side of each treated tree. For trickle irrigated trees, the highest concentration of roots was found around the emitters, particularly at 30 to 90 cm deep, but some roots appeared to be located below the 120 cm depth. Root distribution was similar for the basin irrigated trees, but the highest concentration of roots was found in a larger wetted area near the tree trunk. This treatment had the highest root concentrations, compared to all other treatments. Root distribution of trees irrigated by spray irrigation was similar to the basin treatment, except that root spread was not as extensive. Roots of trees irrigated by sprinkler and flood were distributed more randomly, and were more likely to extend past the drip line, compared to the other treatments. Root concentrations also declined with increasing depth.

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DESICCATION AVOIDANCE OF APPLE TREES WITH N-2001 ANTITRANSPIRANT

Sung H. Guak*, L. H. Fuchigami, and Charles C. Shin*, Department of Horticulture, Oregon State University, ALS 4017, Corvallis, OR 97331-7304, Great Lakes Chemical Corp., P.O. Box 2200, West Lafayette, IN 47906.

Antitranspirant N-2001 (10%), Great Lakes Chemical Corporation, was applied as a soil drench to 'Fuji'/'EMLA7' apple plants growing in 15 cm pots in a 25/22±3°C (D/N) greenhouse. After bringing pots to field capacity, chemical application was made and water was withheld thereafter. One hour after chemical application, stomatal conductance of treated and control plants was 0.25 and 0.70 cm/sec, respectively. Stomatal conductance of treated plants was maintained at approximately 0.25 cm/sec throughout the test period (28 days). Stomatal conductance of the control plants decreased to 0.25 cm/sec 13 days after treatment due to desiccation. The stem xylem water potential of the treated and control plants was -2.0 and -5.5 MPa, respectively, 28 days after treatment. The relative water content of leaves of treated plants was 45% greater than controls. The average loss of water via transpiration of treated plants was 32% less than the control plants.

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PB 277

INFLUENCE OF IRRIGATION FREQUENCY ON GROWTH OF BLACK MAPLE AND SUGAR MAPLE

William R. Grave*, Department of Horticulture, Iowa State University, Ames, IA 50011-1100

Differences in native habitat and leaf morphological traits have prompted speculation that black maple (*Acer nigrum* Michx.f.) is more drought resistant than sugar maple (*A. saccharum* Marsh.). In this study, growth of potted seedlings of the two species irrigated at 10-, 26-, or 42-day intervals was compared. For plants irrigated most frequently, dry mass, shoot : root ratio, stem length, and surface area of lamina were greater for sugar maple than black maple. The impact of drought was more pronounced in sugar maple than in black maple, causing reductions in stem length of ≈ 60% in sugar maple and ≈ 30% in black maple. Specific mass of lamina tended to be greater for black maple than sugar maple, particularly after drought, and it increased over time in both species. The slower growth, lower shoot : root ratio, and greater specific mass of lamina of black maple indicate it is more drought resistant than sugar maple.

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PB 280

REDUCED WATER SUPPLY AFFECTS FALL ACCLIMATION OF EVERGREEN AZALEAS

Tomasz Anisko and Orville M. Lindstrom*, Dept. of Horticulture, University of Georgia, Georgia Station, GA 30223-1797

Three cultivars of evergreen azaleas, 'Coral Bell', 'Hinodogiri', and 'Red Ruffle', were grown under four watering regimes in containers and placed outdoors or in the greenhouse. The water content of the growing medium was maintained at either 0.3 to 0.4 or 0.5 to 0.6 m³ m⁻³ from June 16 to August 30, when half of the plants under each of these regime was switched to the other watering regime. Freeze tests were conducted on August 30 and October 9, 1993. Injury to leaves, lower, middle, and upper stems was evaluated visually. Acclimation of leaves and upper stems prior to the August test, in most cases, was not stimulated by reduced water content, while the response of lower and middle stems was cultivar and location specific. The lower water content treatment after August 30 generally increased freeze tolerance of all plant parts regardless of the previous watering regime. The higher water content treatment after August 30 either prevented or delayed acclimation.

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PB 303

POINSETTIA WATER USE INFLUENCED BY ENVIRONMENTAL CONDITIONS AND NUTRIENT SOLUTION CONCENTRATION

Richard J. McAvoy and Bernard B. Bible, Department of Plant Science, Xiusheng Yang, Department of Natural Resource Management and Engineering University of Connecticut, Storrs, CT 06269-4067.

Poinsettias were grown in a closed hydroponic system with a modified Hoagland's solution concentration of either 1 or 3 mS·cm⁻¹. Water use and whole plant fresh mass were measured gravimetrically at 2 to 3 day intervals over an eleven week period (initial break development through full bract development). At two week intervals, poinsettias were harvested and the fresh and dry mass of leaves, bracts stems, and roots were determined, and total laminar surface area was measured. Leaf temperature (LT), root-zone solution temperature (RZT), and at canopy level, air temperature (CAT), VPD, and photosynthetic photon flux (PPF) were monitored at 1 mm intervals and mean values recorded each 30 mm using a 21X micrologger (Campbell Scientific, Logan Utah). Water use (ml·dm⁻²·day⁻¹) averaged 15% higher for poinsettias grown in the 1 mS·cm⁻¹ solution than in the 3 mS·cm⁻¹ nutrient solution. Simple linear regression of daily water use with PPF, or VPD, or CAT, while significant, accounted for less than half of the daily fluctuation in water use (r²; PPF= 0.47, VPD=0.21, CAT=0.30). However, multiple regression involving daily PPF, VPD, CAT, RZT and LT accounted for up to 82% of the variation in daily water use.

100 POSTER SESSION 16 (Abstr. 698-732) Postharvest/Food Science

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PB 306

WETTABILITY AND SURFACE TENSION OF FRUIT SURFACES

Cisneros-Zevallos, L.*, Saltveit, M. E. and Krochta J. M,
Dept. of Food Science & Technology, Univ. of California
Davis, CA 95616.

Nettability is an important factor to be considered in postharvest treatments such as washing, aqueous dippings, coatings, etc. Pome fruits (ten apple and four pear cultivars) and stone fruits (nectarine and plums) were evaluated for wetting behavior and surface tension at room temperature. Nettability was assessed by measuring contact angles of water. Surface tension was calculated by measuring contact angles of methylene iodide and water or by a series of pure surfactants using Zisman's method. Wetting behavior on apple fruits depended on cultivar, with water contact angles ranging from 75° to 131°. For pear fruits, wetting also depended on cultivar. Calculated surface tensions of pear fruits were in general higher than most apple cultivars tested. In stone fruits, plums presented a high water-repellency with a contact angle of 137°.

The wetting of fruit surfaces seems to be governed by the nature of the chemical groups exposed on the surface of the cuticle and also by the surface roughness, as evidenced by tire high values of some contact angles.

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PB 309

THE MODE OF CO₂ ACTION ON ACC OXIDASE AND ITS ROLE IN INHIBITION OF ETHYLENE BIOSYNTHESIS

James R. Gorny* and Adel A. Kader, Department of Pomology,
University of California, Davis, CA 95616

Ethylene biosynthesis of Golden Delicious apple fruit at 20°C is rapidly inhibited by a controlled atmosphere of air + 20% CO₂. However, *in vitro* ACC oxidase activity and ACC content were not significantly different between air and air + 20% CO₂ treated fruit. To determine the *in vivo* effects of CO₂ treatment, both *in vivo* and *in vitro* enzyme activity essays were performed in an atmosphere of air or air + 20% CO₂. Western blots were also performed to quantify the amount of ACC oxidase protein present in the air and air + 20% CO₂ treated fruit.

We believe that *in vivo* cytosolic pH changes, induced by CO₂, may reduce the *in vivo* catalytic capacity of ACC oxidase, end hence significantly reduce ethylene biosynthesis in climacteric tissue,

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EFFECT OF PRE-HARVEST CALCIUM APPLICATIONS ON FIRMNESS, DECAY, AND MINERAL DISTRIBUTION IN STRAWBERRY FRUIT

D. J. Makus and J. R. Morris*, USDA, ARS, CPSR, Waslaco, TX 78596 and Dept.
Food Science, University of Arkansas, Fayetteville, AR 72703

Supplemental calcium supplied foliarly as Ca glutarate, soil incorporated as gypsum, fertigated as CaNO₃, in 3-way combination, or none at all, had no effect on fruit firmness, as measured by shear, reduced fruit decay by as much as 23% over controls (1986-1988), and generally improved fruit Ca levels only in the combination treatment of 904 kg/ha. Fruit raw product quality (pulp pH, acidity, soluble solids concentration, and Hunter color values) were not consistently affected, although there were significant interactions between cvs Fern and Cardinal, harvest dates, holding time, and years. Supplemental Ca reduced fruit size, but tended to increase yield. In 1988, individual fruits were partitioned into upper/lower, dermal/interior, and upper/lower seeds (6 parts), Ca was the third most abundant mineral nutrient in receptacle tissue, but most abundant in seeds. Highest Ca levels were found (descendingly) in the seed, dermal, and interior pulp tissue, Ca was higher in the upper (stem) end. Differences in fruit Ca levels between cvs were found in the seeds and not the receptacle. No clear relationship was observed between fruit firmness, decay, and Ca level.

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PB 315

SOUTHERN Highbush BLUEBERRIES DIFFER IN POSTHARVEST QUALITY

¹P. Perkins-Weazie*, ²J. K. Collins, ³J. R. Clark, and ⁴J. Magee
^{1,2}USDA-ARS, South Central Agric. Res. Lab., Lane, OK, 74555;
³Dept. Hortic. and Forestry, Univ. Arkansas, Fayetteville, AR
72701; ⁴USDA-ARS Small Fruits Res. Stat., Poplarville, MS 39470

Although several new southern highbush blueberry cultivars have been introduced, little is known about their shelflife quality. Five southern highbush cultivars and three advanced selections were harvested from plantings at Clarksville, Ark. and held at 5C, 95% RH for 21 days followed by 1 day at 20C. 'Gulf Coast' fruit had the most and 'A109' the least weight loss after storage (12% and 6%). 'Gulf Coast' fruit were rated softest after storage, Anthocyanin content was highest in 'Cape Fear' and lowest in 'MS108' (142 and 57 abs. units/g FW, respectively). After storage, total anthocyanin content increased 60% in 'Cape Fear' and 'O'Neal' fruit. Fruit pH was higher in stored fruit but titratable acidity decreased only in 'O'Neal', 'Sierra', and 'G616' fruit. Results indicate that southern highbush blueberries cultivars show great variability in shelflife quality.

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PB 318

SHELF- LIFE AND PHYSIOCHEMICAL PROPERTIES OF HIGHBUSH (*VACCINIUM CORYMBOSUM*) AND RABBITEYE (*V. ASHEI*) BLUEBERRIES FOR FRESH MARKET

E. Marroquin, J. L. Silva*, J. O. Garner, J. B. Magee, J.
Braswell, and J. Spiers, Dept. of Food Science & Technology,
Miss. State Univ., Box 9805, Miss State, MS 39762

Three varieties of rabbit eye (*Vaccinium ashei*) blueberries ('Climax', 'Premier', and 'Tifblue') were harvested in Mississippi and two varieties of highbush (*V. corymbosum*) blueberries ('Bluecrop' and 'Jersey') were harvested in Michigan. Each variety was harvested at three different locations as replications. The berries were rapidly cooled to 5°C after harvest, placed in 1-pint containers, and analyzed at 7-day intervals for 28 days with day 0 being 48 h after harvest.

Shear, compression and puncture forces were higher for rabbiteye spp. than for highbush spp. 'Bluecrop' blueberries showed the lowest shear force whereas 'Climax' had the most shear force. Puncture force (skin toughness) was lower for 'Bluecrop' and 'Jersey' and higher for 'Climax'. There was an increase in shear force by all varieties with storage time. 'Premier' and 'Climax' had lower soluble solids, but they increased with storage time. 'Jersey' had the highest pH and 'Tifblue' the lowest. Although all varieties lost moisture with time, 'Bluecrop' always had higher moisture. Mold growth varied with time; however, 'Bluecrop' had a higher percentage of moldy berries throughout refrigeration. The percent decay was higher for highbush blueberries after 16 d of refrigeration. Rabbiteye's toughness and firmness give them a longer refrigerated shelf-life over highbush blueberries.

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THE RELATIONSHIP BETWEEN FRUIT ELASTICITY, INTERNAL CARBON DIOXIDE AND STANDARD MATURITY INDICES FOR APPLE FRUIT ATTACHED TO THE TREE

Randolph Beaudry*, Paul Armstrong, and Galen Brown, Departments of
Horticulture (RB) and Agricultural Engineering (PA) and USDA-ARS
(GB), Michigan State University, East Lansing, MI 48824

Elasticity, internal C₂H₄, CO₂, and O₂, diameter, firmness, and starch index were determined for ripening 'McIntosh', 'Red Delicious' and 'Golden Delicious' apple fruit. Elasticity, measured by the acoustic impulse response of the apple, has previously been found to correlate with fruit firmness after harvest (Armstrong and Brown, 1992) and was studied as a possible index of apple harvest maturity because it is a rapid, non-destructive measurement that could be adapted for field use. However, elasticity did not correlate with firmness or other maturity parameters for fruit attached to the tree. Fruit temperature influenced internal gas levels, probably due to its effect on metabolic activity. An increase in the temperature-compensated internal CO₂ level occurred for fruit having an elevated internal C₂H₄ concentration (> 0.02 µl/L), which suggested that the climacteric respiratory increase associated with ripening occurred while fruit were attached to the tree.

EFFECT OF METHYL JASMOMATE ON ETHYLENE PRODUCTION AND VOLATILE SYNTHESIS DURING RIPENING OF 'SUMMER RED' APPLES

Xuetone Fan* and James P. Mattheis, Department of Horticulture and Landscape Architecture, Washington State University, Pullman, WA 99164-6414 and USDA-ARS, Tree Fruit Research Laboratory, 1104 N. Western Ave. Wenatchee, WA 98801.

Jasmonic acid and its methyl ester (methyl jasmonate), regarded as putative plant growth regulators, are naturally occurring in higher plants and present in a variety of plant organs including apple fruit. Pre- and post-climacteric 'Summer Red' apples were exposed for 12 hrs to a low concentration (25ul/4L) of atmospheric methyl jasmonate. Ethylene and volatile production were measured with GC/MS at harvest and through 15 days at 20°C after treatment. Forty eight headspace volatile compounds were identified and quantified. Results showed that methyl jasmonate effects depended on stage of fruit development. Methyl jasmonate stimulated ethylene, ester, alcohol, and acid productions in preclimacteric fruits while no significant effects were observed on postclimacteric fruits. Ketone and aldehyde volatile evolutions were not significantly affected by methyl jasmonate regardless of harvest date.

MEMBRANE LIPID COMPOSITION DURING RIPENING OF CALCIUM-INFILTRATED APPLE FRUIT

G.A. Picchioni*, A.E. Watada, W.S. Conway, and B.D. Whitaker, Horticultural Crops Quality Laboratory, ARS, USDA, Beltsville, MD 20705-2350

Postharvest Ca infiltration delays senescence and improves storage quality of apple fruit, but the consequences on membrane lipid composition have received little evaluation. We studied changes in galactolipids (mono- and digalactosyl-diacylglycerol; MGDG and DGDG) and sterol conjugates (sterol glycosides and acylated sterol glycosides; SG and ASG) in 'Golden Delicious' cortical tissue. Fruit were pressure-infiltrated with CaCl₂ at harvest (0, 2, or 4% w/v), stored for 6 months at 0°C, and evaluated during subsequent exposure to 20°C. MGDG, SG and ASG concentrations were greater in Ca-infiltrated fruit (CIF) than in control fruit. A 35-37% increase in ASG occurred during the first 7 days at 20°C in CIF, when ASG decreased by 19% in control fruit. Ca infiltration may delay degradation of plastid membranes and increase sterol conjugation during apple fruit ripening.

EPICUTICULAR WAX STRUCTURE AND POSTHARVEST CALCIUM UPTAKE IN 'GOLDEN DELICIOUS' APPLES AT VARIOUS INTERVALS AFTER STORAGE

Stephane Roy^{1,2}, William S. Conway^{1*}, Alley E. Watada¹, Carl E. Sams³, and William P. Wergin², Horticultural Crops Quality Lab¹, Electron Microscope Lab², USDA, ARS, Beltsville, MD 20705, The Univ. of Tennessee³, Knoxville, TN 37901.

Increasing the calcium content of apples with postharvest CaCl₂ treatment has a beneficial effect on physiological and pathological storage problems. The optimal time after harvest during which the fruit can be successfully treated has not been investigated. This study examined the relationship between calcium uptake and the changes in surface cracking in the epicuticular wax of the fruit after various storage intervals. Apples were pressure infiltrated with 0, 2, or 4% CaCl₂ solutions at harvest or four or six months after storage at 0°C. Examination of the epicuticular wax with low temperature scanning electron microscopy revealed that as the storage duration increased, the numerous cracks on the fruit surface became deeper and wider, until, after six months storage, the cracking extended through the thickness of the cuticle. Calcium uptake in fruit pressure infiltrated with the CaCl₂ solutions after six months storage was greater than fruit treated at previous storage intervals. As storage duration increased, epicuticular wax cracks became deeper and calcium uptake increased.

MODIFICATION OF EPICUTICULAR WAX STRUCTURE BY HEAT-TREATMENT IN 'GOLDEN DELICIOUS' APPLES AND ITS EFFECT ON POST HARVEST CALCIUM UPTAKE

S. Roy, W.S. Conway^{1*}, A.E. Watada¹, C.E. Sams³, Eric F. Erbe² and W.P. Wergin², Horticultural Crops Quality Lab., Electron Microscopy Lab., USDA, ARS, Beltsville, MD 20705, The University of Tennessee, Knoxville, TN, 37901.

Prestorage heat treatment of apples has been shown to have a positive effect on fruit quality in storage. Postharvest treatment of apples with CaCl₂ also beneficially affected fruit during storage. However, calcium uptake seems limited in heat-treated apples which indicates that the surface of the fruit may have been affected by the heat treatment. This study examined the effect of heat treatment on the subsequent uptake of CaCl₂ solutions and related this process to the ultrastructure of the epicuticular wax surface of the fruit. Apples were pressure infiltrated with a 4% CaCl₂ solution either without heat treatment or following 4 days at 38°C. Examination of the apple surfaces with low temperature scanning electron microscopy revealed that heat treatment changed the pattern of epicuticular wax. The epicuticular wax of non heated fruit exhibited numerous deep surface cracks. The epicuticular wax of heated fruit did not exhibit similar cracks. This apparent obstruction or elimination of deep cracks may limit the CaCl₂ solutions from entering the fruit. The heated fruit contained significantly less calcium compared to the fruit that were pressure infiltrated with the CaCl₂ solution but not heated. These results indicate that cracks on the fruit surface may be an important pathway for the penetration of CaCl₂ solutions.

PREDICTING SUPERFICIAL SCALD ON 'DELICIOUS' APPLE

Sarah A. Weis and William J. Bramlage*, Dept. of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003-0910

Fruit from five regions worldwide were rated for scald development after four months in 0°C air plus one week at 20°C. Scald incidence was quantitatively related to preharvest temperature conditions and fruit maturity, as measured by starch index. Various low temperature cutoffs were used, and high temperatures over 30°C were also used in the equations. Where data were available light conditions and rainfall were included in the equations. Several models were developed and tested to determine if prediction equations could be of commercial value. The most successful equations explained over 50% of the variation in scald. While they could not predict exact percentages of fruit which would develop scald, equations could predict cases of very high and very low scald, thus identifying fruit requiring the greatest scald control measures and those needing minimal scald control action.

SPECTROPHOTOMETRIC CHARACTERIZATION OF STORAGE SCALD DISORDER IN BARTLETT, PACKHAM'S TRIUMPHED 'ANJOU' PEAR FRUIT VARIETIES.

Juan P. Zoffoli*, Daryl Richardson, David Sugar, and Paul Chen Oregon State University, Dept. of Horticulture, Corvallis, OR 97331

The brown color development on the skin of three varieties of pears (Bartlett, Packham's T. and Anjou) was characterized between 200 and 300 nm from hexane extracts of pear peel discs, with and without the application of the antioxidant Ethoxyquin (2700ppm) during -1°C storage and 20°C ripening. All the varieties presented a main peak at 232nm (a farnesene), which decreased in the storage as scald increased.

Absorbance at 259, 269, and 280nm (conjugated trienes) were characteristic of Anjou and Packham's Triumph fruits susceptible to the disorder. Bartlett fruits had a major peak at 259nm without the other secondary peaks.

The application of ethoxyquin reduced the oxidation of a farnesene, the formation of the conjugated trienes and intensity of scald in Packham's Triumph and Anjou fruits. However in Bartlett fruits this antioxidant was not very effective to reduce the scald.

HARVEST MATURITY STAGE AFFECT PEACH QUALITY DURING COLD STORAGE.

Armida Rodriguez-Felix*, Evelia Araiza-Lizalde, Monica A. Villegas-Ochoa, Elsa Brineas-Taddei, CIAD, A.C., Apdo. Postal 1735, Hermosillo, Sonora, 83000, Mexico. CIAD/DTAOV/RC/007/94.

Physico-chemical and physiological changes of 'Flordaprince' peach fruits harvested at different maturity stages were evaluated during low temperature storage. Harvested fruits were immediately classified into four different maturity stages based on red-skin color (I, 20%; II, 40%; III, 60%; and IV, 80%). Fruits were stored at 2°C (90% R.H.) for 0, 15, and 30 days.

Following cold storage conditions, fruits were transferred to a 20 C room. Physico-chemical and physiological characteristics evaluated during storage included weight loss, firmness, pH, titratable acidity, skin color (hue), total soluble solids, respiration rate, and ethylene production. Weight loss increased (up to 40%) after 27 days storage at 2C. The fruits harvested at maturity stage I showed the lowest weight loss. Flesh firmness decreased significantly during storage at 2 C. Fruits from stages I and II had higher firmness than fruits harvested at stages III and IV. A significant change from green-yellow to red color was observed in fruits of the distinct maturity stages during storage at 20 C.

711 PB 385
EFFECTS OF TEMPERATURE, GAS COMPOSITION, AND STORAGE ON THE O₂ CONSUMPTION OF 'RED GOLD' NECTARINES.

Maria B. Omary*, Robert F. Testin¹, and Nihal C. Rajapakse².
¹Department of Food Science, ²Department of Horticulture, Clemson University, Clemson, SC 29634.

The influence of 3 temperatures (1, 10 and 25°C). 9 combinations of initial O₂ (5, 10 and 20%) and CO₂ (0, 10 and 20%) concentrations, and 3 storage durations at 1°C (2, 13 and 24 days) on the O₂ consumption of 'Red Gold' nectarines was investigated. Fruits were sealed in glass jars, flushed with respective gas mixtures and stored in dark incubators maintained at 1, 10 or 25°C. Head space O₂ concentration was monitored at selected intervals until it dropped down to 1% or less. The oxygen consumption rate decreased significantly with decrease in temperature and initial O₂ concentration. The O₂ consumption rate increased as storage duration increased. The range of initial CO₂ concentrations used in this study had no effect on O₂ consumption rate. An empirical model was developed to estimate O₂ consumption rate of 'Red Gold' nectarines as a function of temperature, initial O₂ and CO₂ concentrations and storage duration.

712 PB 388
PACKINGHOUSE OPERATIONS AFFECT PEACH QUALITY DURING STORAGE.

Armida Rodriguez-Felix*, Evelia Araiza-Lizarde, Monica A. Villegas-Ochoa and Elsa Brineas-Taddei. CLAD, A.C., Apdo. Postal 1735, Hermosillo, Sonora, 8300. Mexico. CIAD/DTAOV/RC/008/94.

'Flordaprince' peach quality characteristics were evaluated during cold storage after passing thru different packinghouse operations. Fruits were sampled at three points in a commercial packinghouse as follows: (A) upon arrival at a peach packinghouse, (B) after hydrocooling, and (C) after grading and sorting. After sampling, fruits were stored at 2 C (90 % R.H.) for 0, 15, and 30 days. Following the cold storage periods, fruits were transferred to 20 C. Quality characteristics evaluated during cold storage or marketing conditions consisted of weight loss, firmness, skin color (hue), total soluble solids, titratable acidity, respiration rate, and ethylene production. Peaches stored for 27 days at 2 C had up to 40% weight loss. Additional weight loss was observed during marketing conditions at 20 C (up to 70 % weight loss). Selected peaches after grading and sorting (point C) had the highest weight loss during storage at 2 C, as compared to the other two sampling points. Flesh firmness decreased significantly after 3 days storage at 20 C in all representative points. Weight loss and firmness were the quality attributes that mainly affect peach storage life.

713 PB 391
RELATIONSHIP OF MACRO-MINERAL NUTRITION ON FRUIT POSTHARVEST PERFORMANCE IN 'HAYWARD' KIWI FRUIT

Sanliang Gu*, R. Scott Johnson, Carlos H. Christo, Robert C. Cochran, and David Garner, University of California, Kearney Agricultural Center, 9240 S. Riverbend Avenue, Parlier, CA 93648

Fruit from 8 'Hayward' kiwifruit vineyards in central California were harvested at 2 week intervals after soluble solids content (SSC) reached 6% and subjected to 4 and 6 months of storage at 0°C in an ethylene free environment. Macro-nutrients were analyzed from leaf and fruit tissues. Leaf petiole N and NO₃⁻-N were 2 to 3 times higher for vines that had softer fruit after long-term storage. Where the correlations were significant, fruit firmness and SSC were correlated negatively with N, P, K, Cl, and N/Ca and positively with Ca and Mg of leaf and fruit tissues. The significance of the correlations depended on the harvest maturity and growing locations. Soil nitrogen application increased Mg and reduced Ca and Cl in lamina but did not influence macro-nutrients in fruit tissues.

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714 PB 394
CHANGES IN AVOCADO FRUIT MEMBRANE LIPIDS DURING CONTROLLED ATMOSPHERE STORAGE AND RIPENING.

Dana F. Faubion and Adel A. Kader, Department of Pomology, University of California, Davis, CA 95616

California grown 'Hass' avocado fruit were stored at 5C, in air or a controlled atmosphere (CA) of 2% oxygen and 5% carbon dioxide. Fruit were evaluated at 0, 3, 6, and 10 weeks, both immediately upon removal from storage and after 5 days at 20C. Severe chilling injury developed in the air-stored fruit after six weeks, while only moderate symptoms were observed in CA stored avocado fruit after 10 weeks. Lipid peroxidation breakdown products increased during storage and ripening in both air and CA treatments. Sterols, sterol esters, glycolipids, and phospholipids were analyzed. There was a shift in composition during storage towards increasingly saturated fatty acids. The fatty acid shift was greater in air, than in CA stored fruit. Results will be discussed concerning their relevance to chilling injury development.

715 PB 397
EFFECT OF COATINGS ON FRESH ORANGE FLAVOR VOLATILES AND OTHER FACTORS UNDER PROLONGED STORAGE CONDITIONS

Elizabeth A. Baldwin*, Myrna O. Nisperos-Carriedo and Jacqueline K. Burns, USDA/ARS Citrus and Subtropical Products Laboratory, P.O. Box 1909, Winter Haven, FL 33883 and Citrus Research and Education Center, 700 Experiment Station Rd., Lake Alfred, FL 33850

'Valencia' oranges were-treated with an experimental polysaccharide-based coating, a commercial shellac-based water wax, or were left uncoated. The fruit were stored at 16 or 21C with 95% RH. Samples were periodically analyzed for internal gases, flavor volatiles, water loss, and 'Brix'. Coated fruit had lower internal O₂ and higher CO₂ and ethylene levels as well as higher levels of many flavor volatiles (including ethanol) compared to uncoated. The differences were greatest for shellac-coated fruit at the higher storage temperature. No differences were found for 'Brix'. The shellac-coating gave the best weight-loss control and the most restricted gas exchange. The low gas permeability characteristic of this type of shellac coating may result in altered flavor for fruit held at 21C.

716 PB 400
THE EFFECT OF PACKING DELAYS ON THE FRUIT QUALITY OF VALENCIA ORANGES. M. L. Gottlieb* and M. L. Arpaia, Botany and Plant Sciences Dept., University of California, Riverside, CA 92521.

A major outlet for California Valencia orange fruit is the export market. Transit time to Pacific Rim markets varies from ca. 20 to 40 days. This coupled with delays in packing and cooling ranging from 1 to 3 days may negatively affect fruit quality at the destination market. A study was conducted which examined cooling/packing delays (6, 24, 48, 72 hrs), storage temperature (5, 11C) and duration (3, 6 wks) following packing to evaluate the effect of these factors on the postharvest quality of Valencia orange. The following parameters were monitored: peel penetration force, peel color (L*, Chroma, Hue°), weight loss, external appearance (0-5), decay, and changes in carton pack height. Weight loss prior to packing was directly related to the duration of the prepack delay. This relationship, however, did not continue through storage and simulated marketing. Fruit subjected to delayed packing, however, had lower pack heights and higher external ratings following storage. Storage at 11C resulted in decreased penetration force, higher levels of decay and greater color development and weight loss. Storage for 6 weeks resulted in decreased penetration force, higher weight loss and greater color development.

717 PB 423
ETHYLENE DEGASSING OF GRAPEFRUIT

Peter D. Petracek, Florida Department of Citrus. CREC, Lake Alfred, FL 33850

Early-season fresh citrus are routinely exposed to ethylene to trigger chlorophyll degradation (degreening) in the peel and thus improve fruit color. Recent questions about whether ethylene is trapped in the fruit by subsequent waxing have sparked interest in characterizing ethylene exchange. Internal gas samples of mature, pesticide-free 'White Marsh' grapefruit were taken through septa of silicone rubber on electrical tape affixed 10 the blossom end. Gassing of the fruit in a degreening room (10 ppm ethylene) required about four hours to reach equilibrium while degassing was completed in less than two hours and was not affected by location of the fruit in a 0.680 m³ pallet bin. Waxing with a water-soluble wax immediately following ethylene exposure increased the time for complete degassing to over 48 h. Surface gas exchange profiles were prepared by sequentially analyzing the same fruit after: (1) harvest, (2) 22 h exposure to 10 ppm ethylene, (3) exposure to ethylene and washing with an ionic cleaning surfactant, and (4) exposure to ethylene and waxing. Glass cells with interfacing silicone rubber o-rings (23 mm diam.) were strapped to the fruit following each treatment. Ethylene emanation was

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measured by sampling the cells which were capped 15 m after removal from ethylene. Water and CO₂ were measured by flow-through cells following ethylene analysis. Ethylene emanation following the initial exposure was the same for the stem end and midsection and two fold greater than the blossom end. Washing increased the rate of emanation five fold for the stem end and about 2.5 fold for the midsection and blossom end. Waxing reduced emanation by nearly four fold for the midsection and blossom end, but only 30% for the stem end. Water loss was increased about 40% by washing, reduced about 30% by waxing, and was primarily through the stem end. Stem-end CO₂ exchange doubled upon waxing.

718 PB 426

PHYTOTOXICITY OF METHYL BROMIDE FUMIGATION TO CITRUS FRUIT PACKED IN SHIPPING BOXES

Laurie G. Houck*, Joel F. Jenner and Bruce E. Mackey. USDA-ARS Postharvest Quality and Genetics Unit, Horticultural Crops Research Laboratory, 2021 S. Peach Ave., Fresno, CA 93727

Commercially packed lemons (*Citrus limon* (L.) Burm.), grapefruit (*C. paradisi* Macfayden) and oranges (*C. sinensis* (L.) Osbeck) from CA and AZ were fumigated in corrugated fiberboard shipping boxes with methyl bromide (MB) at doses efficacious for controlling various postharvest insect pests. Fruit developed no rind injury when fumigated at 24 or 32 g MB/m³ for 2 hr at 21C. At 40 g MB fruit developed slight to moderate peel injury, and sometimes there were more decayed fruit. More rind injury developed at 48 gm MB, the injury was more severe, and there were more decays. Curing fruit for 3-4 days at 15-20C before fumigation, and extending the aeration period after fumigation from a few hours to 1 or 3 days reduced fruit injury. Early-season fruit were not injured as severely as late-season fruit. Lemons picked with green-colored peel but fumigated after they turned yellow (by holding at 13C for 4-10 weeks to degreen) were not injured as much as silver or yellow lemons.

719 PB 429

EFFECT OF GIBBERELIC ACID ON CERTAIN PHYSICAL AND CHEMICAL PROPERTIES OF GRAPEFRUIT PEEL

Roy E. McDonald*, USDA, ARS, U.S. Horticultural Research Laboratory, 2120 Camden Road, Orlando, FL 32803 and Philip E. Shaw, USDA, ARS, Citrus and Subtropical Products Laboratory, P.O. Box 1909, Winter Haven, FL 33883.

Preharvest gibberellic acid (GA) applications at 10 ppm in 0.1% L-77 (v/v) surfactant or 20 ppm in 0.05% L-77 (v/v) caused 'Marsh' grapefruit (*Citrus paradisi* Macf.) to be significantly more resistant to puncture and significantly delayed yellow color development. There was no difference between the two GA rates and applications in July were not found to be as effective as August or September applications. There was an overall significant increase in peel oil content in flavedo tissue as a result of GA treatment, but no significant difference between GA treatments. Limonin contents in GA-treated grapefruit albedo tissue were generally higher at both GA levels than in control fruit. GA treatments had no effect on juice quality characteristics and there was no difference in taste preference between GA-treated and control fruit. Because citrus fruit are resistant to attack by tephritid fruit flies prior to the occurrence of peel senescence and GA delays peel senescence, GA treatment should provide a biorational addition to existing fruit fly control strategies.

720 PB 432

THE EFFECT OF APPLYING CALCIUM ON THE RIPENING OF MANGO FRUITS (*Mangifera indica* L.)

Judith Zambrano* and Juan Manzano.

NURR, Universidad de Los Andes, Trujillo, Venezuela and Posgrado de Horticultura, UCLA, Barquisimeto, Venezuela.

The effect of applying Ca++ in two forms: infiltration and dipping on mango fruit cv 'Haden' was investigated. This effect was evaluated by measuring some quality parameters in the flesh and in the skin of the fruit. It was found that postharvest application of Ca++ extent the storage life of the fruit by a week. This fact, together with the results obtained from the quantification of sugars, ascorbic acid, total soluble solids alcohol, insoluble solids, starch and titrable acidity seem to indicate that the application of Ca++ delays slightly the process associated with ripeness. Furthermore, no significant difference between the two forms of Ca++ applied was found, except for the amount of ascorbic acid and total sugar. Finally, dipping application of Ca++ is easier than infiltration and it is therefore suggested.

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721

PB 435

EFFECT OF ANAEROBIC CONDITIONS ON VOLATILE COMPOUNDS OF RIPENING BANANA.

Theeranuch Chantachit and Daryl G. Richardson. Dept. of Horticulture. Oregon State Univ., Ag and Life Sci. 4017. Corvallis, OR 97331-7304.

Ripening bananas (color stage 5) were placed in closed jars held at 20°C. Nitrogen (99.99%, 100 ml/min) or air were flowed through the jars. SPME (Solid Phase Micro Extraction) was used for sampling dynamic headspace and analyzed by GC-MS and GC-FID. Several volatile compounds decreased with time in the nitrogen treatment. Production of isobutyl butyrate, 3-methyl-1-butanol, methyl heptanoate, pentyl acetate, and 2-pentanol which were present in air treatments, were absent in the nitrogen treatment. Ethanol rapidly increased until the last day. Off-flavors were detected by most panelists after three days of N₂ treatment and off-flavors increased in the following days. Reversibility of off-flavor after exposing the bananas to air was not detected by panelists. Correlations were low between the main compounds in the nitrogen treatment and the off-flavor score.

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PB 438

FRUIT QUALITY OF STRAWBERRY GUAVA

Hiroo Mukai*, Toshihiko Takagi, Yasuhiro Nakamura and Tetsuo Suzuki, Faculty of Agriculture, Shizuoka University, Shizuoka 422, Japan

Fruit quality of strawberry guava, yellow strawberry guava (*Psidium cattleianum* Sabine) and red strawberry guava (*Psidium cattleianum* Sabine var. *luidium*) was investigated. Fruit weight of yellow strawberry guava ranged from 7.9 to 39.2 g, and that of red strawberry guava ranged from 3.6 to 15.9 g. Yellow strawberry guava was round, and red strawberry guava was ovoid, in fruit shape. Strawberry guava fruit had many hard seeds. Yellow and red strawberry guava contained 16 to 137 and 5 to 33 seeds per fruit. Seed of red strawberry guava was bigger than that of yellow strawberry guava. Sucrose, glucose, and fructose were contained in strawberry guava fruit. Sucrose, glucose, and fructose contents of yellow strawberry guava fruit were 6.69%, 3.61%, and 6.27%, respectively. Those of red strawberry guava fruit were 9.52%, 2.09%, and 3.39%, respectively. Strawberry guava fruit contained about 1% of titratable acidity. Total ascorbic and dehydro-ascorbic acid contents of yellow strawberry guava fruit were 57.9 mg/100ml and 41.6 mg/100ml, respectively. Those of red strawberry guava were 81.4 mg/100ml and 74.4 mg/100ml, respectively. Fruit quality of strawberry guava was suitable to eat freshly.

723

PB 459

THE POTENTIAL EFFECTS OF POSTHARVEST CALCIUM CHLORIDE DIPS AND LIPID WAX ON RIND BREAKDOWN IN THE CHIRONJA

Arturo Cedeño Maldonado*, Patrick E. Chesney, and Essau Orengo, Department of Horticulture, University of Puerto Rico, Mayagüez, PR 00681.

The chironja (*Citrus sinensis* L. Osbeck* *Citrus paradisi* Macf.) is a citrus hybrid of excellent quality. Attempts at commercialization has been limited by the susceptibility of the fruit to rapid rind breakdown after harvest. A study was undertaken to determine the effects of postharvest calcium chloride (CaCl₂) dips and lipid waxes on rind quality of two chironja clones at two maturity stages. CaCl₂ dips had no significant effect on weight loss irresponsible of clones and maturity. Waxing improved lustre of fruits, retarded aging and shrinkage and slightly inhibited degreening. Pac Rite wax was more effective than Prima Fresh wax. Clone 2-4 was less resistant than clone 3-8 to rind breakdown and made better use of the wax treatments. Mature yellow fruits had a better response to treatments than mature green fruits in retarding weight loss. Untreated fruits deteriorated rapidly after five days. Symptoms of rind breakdown were incipient in calcium treated fruits. Preharvest calcium applications and/or postharvest waxing may reduce the incidence of rind breakdown in the chimnja.

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PB 462

PHYSICO-CHEMICAL PROPERTIES OF GUAVA PRODUCED IN GEORGIA

Umedi L. Yadava*, Plant Science Department, Agricultural Research Station, School of Agriculture, Fort Valley State College, Fort Valley, GA 31030-3298

Fully developed and ripe guava (*Psidium guajava* L.) fruits harvested during Sept-Dec 1993, from field-grown trees which were winter protected by 6-mil clear polyethylene, were examined for physical characteristics and nutrient contents. The purpose of this study was to establish optimum harvest time, fruit yield and physical characters, and nutritional fluctuations over a five week storage time. Fruits picked at turning stage, were observed for fresh weight, fruit girth (horizontal) and height (vertical), fruit volume, and fruit surface & flesh color evaluation (L* a* b* values by chromameter CR-200, Minolta Corp). Nutritional analysis (proximates, vitamins, and minerals) of fruits harvested on Oct 11, Oct 18, Oct 25, Nov 1, and Nov 8 and, refrigerated until analyzed, was performed at Food Science Department, University of Georgia. There were 342 fruits/tree with an average weight of 292 g, fruit girth 26.1" and height 7.5". L* a* b* values for surface and flesh colors were. +65.61, -6.86, +39.37, and

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+55.86, +35.41, +19.48, respectively. Nutritional analyses indicated that the guava fruits were high in vitamin C (305 mg per 100 g fruit). K (201 mg), protein (1.4 g) and total dietary fiber (5.1 g) but low in fat (0.19 g per 100 g fruit) and Na (1.3 mg). The harvested fruit kept well for a five weeks period under refrigerated storage. Except for a modest loss of moisture, the storage period showed no significant effect on nutrient contents in the proximates, vitamins or mineral analyses indicating value of cool storage for guavas.

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FB 465

OCCURRENCE AND IDENTIFICATION OF WHITE MOLD ON HAZELNUT KERNELS.

Kais S. Ebrahim*, Daryl G. Richard

Department of Horticulture, Oregon State University, Corvallis, OR, 97331.

Barcelona, Daviana, and Ennis varieties of hazelnuts were sampled in commercial orchards between Cotvallis and Portland for incidence of kernel white mold. What was thought to be storage mold actually occurred on the trees even when the nuts were in early development. There were significant differences between the three years. Mold incidence was highest in 1986, and lower in 1987 and 1988. There were some differences in mold percent between the samples from tree and ground. *Ramularia* was the only species of fungus that was identified in all samples and was found at high percentages. No incidence of any *Aspergillus* species were found. Temperatures for drying and storage had no effect on mold percentage nor did number of nuts per cluster.

EFFECT OF OXYGEN CONCENTRATION AND RELATIVE HUMIDITY ON THE RANCIDITY PROCESS OF WALNUTS AND PEANUTS

Maté J.I.*, Saltveit M.E. and Krochta J.M.

Dept. of Food Science and Tech., Univ. of California, Davis CA 95616

Rancidity is a major problem during the storage of shelled peanuts and walnuts. Blanched peanuts, blanched dry roasted peanuts, blanched oil roasted peanuts (all of them extra large Virginia variety) and shelled Persian walnut (Chandler variety) were maintained in closed jars at 37 C. Relative humidity was controlled by saturated salt solutions at 20% and 55%. Oxygen concentration was 21% or reduced to 0.1% by flushing with nitrogen.

Samples were taken every 2 weeks for 10 weeks. Peroxide values were measured and volatiles were analyzed to determine the rancidity of the samples. Oxygen concentrations in the jars and nut moisture were also measured.

Dry roasted peanuts were the most susceptible to rancidity. Blanched peanuts, without any roasting process, were the most stable. The results quantified the importance of oxygen as a major factor in rancidity at the relative humidities studied. It was concluded that it is possible to quantitatively control the rancidity process by decreasing the oxygen concentration surrounding the nuts.

OPTIMISATION OF SOLIDS RECOVERY IN CONCENTRATED ORANGE JUICE (COJ) PROCESSING

O. SMITH-KAYODE¹, S.A.O. ADEYEMI¹, REMI ARIBISALA, FUNKE BOGUNJOKO & G.N. ELEMO.

1.National Hort. Res. Inst. Ibadon.

2. Raw Materials Research and Development Council, Lagos, Nigeria.

Conventional procedure for producing concentrated orange juice through evaporation often causes thermally induce gelation with difficulties in raising brix to optimum level. The objective of this study was to determine the effects of mixed pectinase treatment on solids extraction, recovery and pulp wash from selected sweet orange fruit cultivars. Enzyme use level, depectinization time were varied and pertinent rheological parameters determined on concentrate samples towards standardising quality control protocols. The enzyme treatment improved juice circulation in the climbing film evaporator and solids content raised to ≥ 60 Brix.

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PB 474

PARTIAL OIL EXTRACTION OF PECAN HALVES BY SUPERCRITICAL FLUID EXTRACTION

Niels O. Maness*, Jamal Bizri and Michael W. Smith, Department of Horticulture and L. A., and C. Zhang and Gerald H. Brusewitz, Department of Biosystems and Agricultural Engineering, Oklahoma State University, Stillwater, OK 74078.

Partial oil extraction is being investigated as a means to increase oxidative stability and provide reduced fat pecan halves. Supercritical extraction with carbon dioxide provided a means to extract twenty to thirty percent of resident oil, with little to no kernel damage and leaving no harmful residues in the kernel or the extracted oil. Variances in extraction time, temperature, pressure and total carbon dioxide volume used for extraction with a continuous flow extractor will be discussed. Fatty acid composition of oils extracted using supercritical carbon dioxide was essentially the same as oils obtained by solvent extraction and by cold press. Fatty acid yield in the oils was greater for supercritical extraction compared to the other two methods. Oxidative stability for extracted and unextracted pecans, determined using an accelerated aging technique, will be compared. Supported by USDA grant 92-34150-7190 and the Oklahoma Agricultural Experiment Station.

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PB 498

QUALITY EVALUATION OF FRESH PEJIBAYE PALM HEART (*BACTRIS GASIPAE*.)

Catherine G. Cavaletto*, Natalie Y. Nagai. Charles R. Clement

Richard M. Manshardt Department of Horticulture, University of

Hawaii at Manoa, 3190 Maile Way, Honolulu, HI 96822

Fresh pejibaye palm heart samples were evaluated from 1) progenies from the Benjamin Constant population of the Putumayo landrace and 2) progenies from the Yurimaguas population of the Pampa Hermosa landrace. Favorable sensory characteristics included sweetness, tenderness, crispness, and moistness. Negative sensory characteristics found in some samples were astringency and acidity. Sensory scores for astringency and acidity were significantly different ($p=.05$) between sections of the heart. Basal sections appear to be more acid and astringent than the apical sections. Differences in acidity also exist between plants within a progeny ($p=.05$). Percent total soluble solids ranged from 3.0 to 6.6, but no obvious pattern was apparent. Samples were also provided to chefs in upscale restaurants where they received favorable comments.

731

PB 501

INTERGRATING MICROWAVE FOOD PROCESSING INTO PLANTAIN UTILIZATION.

O. SMITH-KAYODE, NATIONAL HORT. RES. INST. IBADAN, NIGERIA

Plantain (*Musa parasidiaca*), a staple among estimated 70 million Africans and popular item in the tropics is emerging as specialty ethnic food product in developed countries. It is suitable as menu item for food service particularly in the ripe form when deep oil fried. The perishability of the fruit is a major constraint to wide spread use and distribution. To expand the utilization base in the food service industry, microwave heating process was applied to tempering and cooking of frozen pre-fried slices. The purpose of this is to determine the effect of the process on warmed over properties and acceptability of fried plantain. Large surface area and spherical shape were critical physical factors in the heating thus providing good quality product from taste, texture and appearance standpoint

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PB 504

JUICE QUALITY FROM YOUNG TREES OF 6 VALENCIA CLONES ON 16 ROOTSTOCKS

Robert E. Rouse*, University of Florida, IFAS, Southwest Florida Research & Education Center, P.O. Drawer 5127, Immokalee, FL 33934

Juice quality from 4-year-old 'Valencia' sweet orange (*C. sinensis* (L.) Osbeck) nucellar seedling clones VS-F-55-28-X-E, VS-SPB-1-14-19-X-E, old-line clones V-10-12-7-X-E, V-51-3-3-(STG-64G-4)-X-E, and 'Rohde Red Valencia' RRV-472-3-26-(STG-31-18)-X-E, RRV-472-11-43-(STG-19-2)-X-E were compared for percentage juice per fruit, "Brix, acid, "Brix/acid ratio, soluble solids per standard 40.9 kg field box, and

juice color score. Rootstocks were sour orange, Smooth Flat Seville, Cleopatra mandarin, Sun Chu Sha, calamandarin, Valencia seedling, *P. myoliare* x Ridge Pineapple X73-26, Duncan grapefruit, Carrizo, Benton and C-35 citranges, Swingle and F-80-18 citrumelos, Rangpur lime x Troyer citrange, *P. trifoliata*, and Vangasay lemon. V-10-12-7 had the most juice. RRV-472-11-43 had less acid than the other clones. VS-SPB-1-4-19 had highest ratio and RRV-472-3-26 the lowest. Soluble solids per box were lowest for RRV-472-3-26. Juice color score was highest for the two 'Rohde Red Valencia' clones and lowest for V-10-12-7. Rootstock affected all juice quality factors except juice color score.

101 POSTER SESSION 17 (Abstr. 733-762) Growth and Development

733 PB 023
PHOTOSYNTHESIS AND MANNITOL/SUCROSE PARTITIONING UNDER DIFFERENT CO₂ ASSIMILATION CONDITIONS IN CELERY
Riccardo Gucci, John Everard, James Flore and Wayne Loesch*, Horticulture, Michigan State University, East Lansing, MI 48824-1325

Photosynthetic rates (A) in celery (*Apium graveolens* L.) and other polyol-synthesizers are sometimes high for C₃ species. In celery such rates have been related to a low CO₂ compensation point typical of C₃ and C₃-C₄ intermediate spp, although other data show celery photosynthesis as typically C₃. Therefore, celery gas exchange was here reanalyzed, and while A was high (CO₂ assimilation rates were 21.2 and 27.6 $\mu\text{mol m}^{-2}\text{s}^{-1}$, average and maximum, photosynthesis was otherwise C₃; CO₂ comp pt of 3.5-5.0 Pa, carboxylation efficiency of 0.99 $\mu\text{mol CO}_2\text{m}^{-2}\text{s}^{-1}\text{Pa}^{-1}$, light comp pt of 8-36 $\mu\text{mol photon m}^{-2}\text{s}^{-1}$, optimum temp of 22-27°C for A_{max}. High A may relate to a capacity to synthesize both mannitol and sucrose. ¹⁴C pulse-chase studies, with different A obtained by imposing light gradients across opposite leaflets, showed 1-10% increases in mannitol sucrose labelling. Higher A may reflect carbon partitioning into mannitol, agreeing with a hypothesis that polyol synthesis effectively recycles reductant in the cytosol.

734 PB 026
EFFECT OF CO₂ LEVEL ON COWPEA CANOPY PHOTOSYNTHESIS AND GROWTH

Tracy A. Ohler* and Cary A. Mitchell
NASA Specialized Center of Research and Training, Purdue University, West Lafayette, IN 47907-1165

The vigorous growth habit and tolerances to heat, water, and acid stresses suggest cowpea as a candidate species for Controlled Ecological Life-Support Systems (CELSS). The low fat, high protein, moderate carbohydrate content of the edible leaves and seeds complement cereal grains in the vegetarian diets planned for CELSS. Cowpea canopy densities of 3.6, 7.2, 10.7, and 14.3 plants·m⁻² were grown under CO₂ levels of 400 or 1200 $\mu\text{l l}^{-1}$. Plants were grown in a deep-batch recirculating hydroponic system. pH was maintained at 5.5 by a pH controller with an in-line electrode. The nutrient solution was replaced as needed and sampled weekly for analysis by inductively coupled plasma-atomic emission spectrometry. Fluorescent lights provided 674±147 $\mu\text{mol m}^{-2}\text{s}^{-1}$ PAR for an 8-hour photoperiod. Day/night temperature was maintained at 27/25°C. CO₂ draw-down within the growth chamber was measured to calculate net photosynthesis. Power consumption was metered and canopy quantum efficiency was calculated. Crop yield rate (g·m⁻²·d⁻¹), harvest index (% edible biomass), and yield efficiency (edible g·m⁻²·d⁻¹/(nonedible g·m⁻²·d⁻¹)) were determined to evaluate the productivity of cowpea for a CELSS. This study was supported by NASA Grant NAGW-2329.

735 PB 029
SORGOLEONE: A PHOTOSYSTEM II INHIBITOR PRODUCED BY *SORGHUM BICOLOR*.

Leslie A. Weston* and Verónica M. Gonzalez, Department of Horticulture & Landscape Architecture, University of Kentucky, Lexington, KY 40546

Sorgoleone, the oxidized quinone form of a hydrophobic p-benzoquinone was first isolated from Sorghum root exudates. Sorgoleone is a potent inhibitor of growth in several annual weed species and causes tissue bleaching at concentrations of <25 μM . These investigations were designed to determine if sorgoleone's allelopathic activity was related to an inhibition of photosynthetic electron transport. The effect of sorgoleone versus DCMU (diuron) on inhibition of O₂ evolution by broken wheat thylakoids, and in

oxygenevolving PSII membranes containing Q_A and Q_B primary and secondary electron acceptors in PSII was determined. Sorgoleone was a potent inhibitor of O₂ evolution in this system with ~ 0.04 and 0.78 μM concentrations required for 50 and 100% inhibition as compared to -0.11 and 2.0 μM DCMU, respectively. Sorgoleone caused no significant inhibition of PSI mediated photooxidation of ascorbate/dichlorophenolindophenol, establishing that the locus of inhibition by sorgoleone was within the PSII complex. The effect of trypsin treatment of chloroplasts and PSII membranes on sensitivity to inhibition by DCMU and sorgoleone was examined. The comparison of DCMU and sorgoleone upon the formation and decay of flash-induced chlorophyll a variable fluorescence indicates that sorgoleone specifically inhibited the oxidation of Q_A by Q_B.

736 PB 032
5-AMINOLEVULINIC ACID DEHYDRATASE ACTIVITY DURING TOMATO FRUIT DEVELOPMENT AND RIPENING

Marios C. Kyriacou*, David J. Hannapel, and Richard J. Gladen, Department of Horticulture, Iowa State University, Ames, IA 50011-1100

Tomato fruit ripening is characterized by a decrease in chlorophyll content and an increase in lycopene synthesis. 5-Aminolevulinic acid (ALA) dehydratase (ALAD) is the fruit committed enzyme in the chlorophyll and heme biosynthetic pathways, and it catalyzes the dimerization of two ALA molecules into porphobilinogen. We have focused our attention on the potential pivotal role of ALAD in the developmental regulation of chlorophyll biosynthesis during tomato fruit growth, development, and ripening. We have standardized an assay procedure for measuring the enzymatic activity of ALAD in tomato fruit tissues. The activity of ALAD was assayed from ten days past anthesis to day 60, when fruits were void of chlorophyll. We observed a several-fold decline in ALAD activity to residual levels during fruit ontogeny. Our data also show greater ALAD activity in chlorophyllous organs (leaves, stems, immature fruits) than in nonchlorophyllous organs (roots, ripe fruits), where heme production is predominant.

737 PB 035
1-UN TOMATO PLANTS TREATED WITH EDTA DO NOT PRODUCE FRUITS THAT TURN RED

Jennifer L. Gisslen*, Cindy B. Tong, and Carl I. Rosen, Departments of Horticultural Science & Soil Science, University of Minnesota, 1970 Folwell Ave., St. Paul MN 55108

It has been reported that 90-day old fruit of *rin* mutant tomato plants treated with nutrient solution containing 1 g EDTA/L attain 98% red coloration of untreated wild-type fruit. We grew *rin* plants in sand and watered with half-strength Hoagland's solution until flowering. After flowering, plants were watered until run-off daily with full-strength Hoagland's solution (control), full-strength Hoagland's solution with 135 μM or 2.5 mM Na₂EDTA, or full-strength Hoagland's solution lacking calcium. We did not observe any red fruit or measure any differences in ethylene production or soluble polyuronides content. Analyses of pericarp ion content indicated that fruit from plants treated with 2.5 mM Na₂EDTA had higher concentrations of sodium and manganese than control fruit. Fruit from plants treated with solution lacking calcium developed blossom end rot and had less calcium and iron than control fruit.

738 Text
ANATOMICAL DESCRIPTION OF THE FRUIT-RECEPTACLE DETACHMENT AREA IN CAYENNE PEPPER

Kay P. Gersch*, Carl E. Motsenbocker, and Gregory A. Lang, Department of Horticulture, Louisiana State University, Baton Rouge, LA 70803

Two genotypes of cayenne pepper, *Capsicum annuum*, have been previously identified which differ significantly in ease of fruit detachment force. Both greenhouse- and field-grown plants of these genotypes, Cajun1-9027 and Cap-9004, were investigated for differences in cell type or organization where the fruit and receptacle join. Scanning electron microscopy revealed that mature fruit of genotype Cajun1-9027, which does not separate, exhibits a distinct region of sclerified cells that extend from the periphery of the fruit into the receptacle for at least 15 cell layers. In contrast, mature fruit of the more readily detachable genotype, Cap-9004, had fewer sclerified cells at the point of detachment. Neither genotype exhibits a well-defined abscission zone prior to, or at, maturity. Interpretation of histochemical staining of fruit-receptacle sections following ethylene treatment at different fruit developmental stages will be discussed.

MYCORRHIZAL FUNGI AND PHOSPHOROUS ENHANCEMENT OF CHILE ANCHO PEPPER (*Capsicum annuum* L. cv. San Luis) GROWTH AND DEVELOPMENT

F.T. Davies, Jr.*, V. Olalde-Portueal, H. M. Escamilla, R.C. Ferrera and M.J. Alvarado, Dept. Hort. Sci., Texas A&M Univ., College Station, TX 77843, CINVESTAV BioTcch Inst., Irapuato, Mexico, ITESM, Queretaro, Mexico and Colegio de Postgraduados, Montecillo, Mexico

In a 3 X 3 factorial experiment, Chile Ancho pepper (*Capsicum annuum* L. cv. San Luis) plants were inoculated or not with VAMycorrhizal (VAM) *Glomus fasciculatum* and a *Glomus sps* isolate from Mexico (ZAC-19). Long Ashton Nutrient solution (LANS) were modified to supply P at 11, 22 or 44 µg/ml to containerized plants, grown in a greenhouse for 72 days. The container medium was a modified 77% sand, 13% silt, 9% clay soil collected from an agricultural production site in Irapuato, Guanajuato, Mexico. Both P and VAM enhanced plant growth and development. Increasing P enhanced leaf area, fruit, shoot and root dry weight and shoot/root ratio; the leaf area ratio (LAR) decreased. Greater VAM growth enhancement occurred at 11 and 22, than 44 µg/ml P. Growth enhancement was greater with *Glomus fasciculatum* than the mixed *Glomus sps* isolate (ZAC - 19).

740

PB 064

DEVELOPMENTAL AND GENETIC DIFFERENCES IN DETACHMENT FORCE OF TABASCO PEPPER

Carl E. Motsenbocker* and Kay P. Gersch, Department of Horticulture, Louisiana State University, Baton Rouge, LA 70803

Field and greenhouse studies were conducted to examine fruit detachment force and plant parameters of two strains of Tabasco (*Capsicum frutescens*) at different stages of maturity. The detachment force of mature red 'McIlhenny Select' at the fruit-receptacle detachment area was less than that of breaker and mature green fruit. 'McIlhenny Select' separated cleanly at all stages of maturity. A wild type Tabasco strain 'HP' did not abscise at the red mature stage; fruit detachment force was greater than that of 'McIlhenny Select'. The detachment force of mature green and breaker 'HP' fruit were similar to those of 'McIlhenny Select' at the same stage of maturity. Fruit weight, length, and width of the two tabasco strains were not different. The utility of the 'McIlhenny Select' and 'HP' strains for physiological studies of pepper fruit abscission will be discussed.

741

PB 067

¹⁴C₂MOVEMENT BETWEEN FLORICANES AND PRIMOCANES IN RED RASPBERRY DURING THE FRUITING CYCLE

Stenhen F. Klauer*, J. Scott Cameron and Paul W. Foote, Washington State University Research and Extension Unit, 1919 NE 78th St., Vancouver, WA, 98665

Results from previous cultural and physiological studies of red raspberry suggest that primocanes compete with floricanes for light, nutrients and/or photoassimilates. This study was undertaken to determine whether this competition might be reflected in the actual translocation of photoassimilates between the two types of canes. In 1993, pairs of greenhouse grown, potted red raspberry (*Rubus idaeus* L.) plants containing one or two floricanes and numerous primocanes were labeled with ¹⁴C₂ on four dates corresponding with early anthesis, green fruit, red fruit and post fruit maturity stages of the growing season. For each experiment, either a floricanes or a primocane was exposed to 92.5µCi ¹⁴C₂ within a sealed bag. After 24 hours, the bag was removed and the presence of label was monitored for up to 11 days. Activity was determined using liquid scintillation. At all developmental stages ¹⁴C moved from the labeled floricanes to primocanes that were from 2.5 cm to 1.5 m tall and to the roots. Movement was quickest and relatively greatest at early anthesis, decreased during fruiting, and was still occurring at 2 months after fruit maturity. Small amounts of label were detected in roots of labeled primocanes at all stages, but trace amounts were present in fruit and other primocanes only at post fruit maturity.

742

PB 070

NUTRITIONAL ANALYSIS OF CHENOPODIUM QUINOA GROWN IN CONTROLLED ENVIRONMENT. HYDROPONIC CULTURE

Greg Schlick and David Bubenheim*, NASA Ames Research Center, Advanced Life Support Division, Moffett Field, CA 94035, USA

Chenopodium quinoa is being considered as a "new" crop for Controlled Ecological Life Support Systems (CELSS) due to the unique protein composition and high mineral values of the seeds and leaves. Quinoa is known to have very high protein levels (12-18% reported from field trials), with desirable amino acid proportions,

and mineral concentrations suitable for a balanced human diet. Controlled environment, hydroponic culture has increased the nutritional value and has the potential of increasing the yield. Protein and mineral values have increased substantially and will be discussed in more depth. The high concentration of protein, unique amino acid profile, high mineral values, versatility in preparation and the potential for increased yields make quinoa a useful crop for CELSS and long-term space missions

743

PB 073

ANATOMICAL AND PHYSIOLOGICAL DIFFERENCES AMONG THREE SPECIES OF *Fragaria*

Bruce D. Kelley* and J. Scott Cameron, Washington State University Research & Extension Unit, 1919 N.E. 78th St., Vancouver, WA 98665

Several anatomical and physiological parameters were measured in 32 genotypes of *fragaia*, including the cultivated strawberry (*frapria x ananassa*) and its progenitor speck *F. chiloensis* and *F. virginiana*. Measurements were made using potted, runner-propagated, & month-old greenhouse-grown plants growing under long day (14/10) conditions.

Significant differences in CO₂ assimilation rates (leaf area and dry weight bases), leaf chlorophyll content, leaf soluble protein content, and leaf anatomy were found between subspecies of *F. virginiana* as well as among species. Recessed stomata and greater water use efficiency were observed in *F. virginiana ssp glauca* as well as in *F. chiloensis* genotypes. In addition, it appears that leaf anatomy characteristics, as studied using light microscopy, may be useful in corroborating taxonomic decisions based upon gross morphology in *Fragaria*.

744

PB 076

IDENTIFICATION OF BOTH ACID AND NEUTRAL INVERTASE ACTIVITY IN DEVELOPING STRAWBERRY FRUIT.

Kirk W. Pomper* and Patrick J. Breen, Dept. of Horticulture, Oregon State Univ., Ag and Life Sci. 4017, Corvallis, OR 97331.

Invertase (INV) may influence sugar levels and assimilate transport in strawberry fruit. Several groups, including our own, have only detected acid INV (optimum pH 4.6) in strawberry fruit, however, recently Hubbard et al. (Physiol. Plant. 82:191-196, 1991) reported the presence of a neutral INV (pH 7.5). Since dissimilar isolation protocols may have contributed to the different findings, we re-examined our work with developing 'Brighton' strawberry using the extraction procedure of Hubbard et al. Neutral INV activity per gFW (pH 7.5-8.0) increased many fold as fruit developed from green to the red ripe stage. Acid INV activity decreased markedly from green-white to the red stage. In addition, when fruit extracts were precipitated with cold acetone, a pellet contained 60% of the acid INV activity, and a surface coagulation of protein contained 60% of the neutral INV activity. This allowed easy separation of these two enzymes. Extraction methodologies affect isolation of neutral INV activity from strawberry fruit.

745

PB 079

SINK SIZE IN GA₃-TREATED AND POLLINATED RABBITEYE BLUEBERRY FRUITS.

Raouel Cano-Medrano* and Rebecca L. Darnell, Horticultural Sciences Department, University of Florida, Gainesville FL 32611

Exogenous applications of GA₃ have induced parthenocarpic fruit set in blueberry; however, size of GA₃-treated fruit is smaller than pollinated fruit. The small fruit size in GA₃-treated fruit may be related to either cell number and/or cell size. Thus, these parameters were examined throughout development in pollinated, non-pollinated and GA₃-treated fruits. Fruit growth followed a double sigmoid pattern. During Stage I (0-25 DAA), fruit size in GA₃-treated, pollinated, and non-pollinated fruits averaged 0.33, 0.39, and 0.16 g, respectively. There was little change in fruit size in Stage II (25-45 DAA). At ripening, fruit size averaged 1.7 g for GA₃-treated and 2.6 g for pollinated fruits. Non-pollinated fruit abscised in Stage II. At anthesis, mesocarp cell number averaged 9910 cells per median cross sectional area and remained constant up to ripening. In Stage I, cell size in GA₃-treated and pollinated fruits increased 7X and 9X respectively. Cell size in both fruit types increased 1.5X and 2.8X during Stage II and Stage III, respectively. Fruit cell number was set at anthesis and differences in fruit size were due to differences in cell elongation in Stage I.

7 4 6 PB 102
DIFFERENCES IN SUCROSE METABOLISM RELATIVE TO
ACCUMULATION OF BIRD-DETERRENT SUCROSE LEVELS IN
FRUIT OF VACCINIUM SPECIES

R.L. Darnell*, R. Cano-Medrano. and K.E. Koch, Horticultural
Sciences Department, University of Florida, Gainesville, FL 32611

Variability in sucrose levels and metabolism in ripe fruit of several
Vaccinium species were examined. The objective was to determine
if sufficient variability for fruit sucrose accumulation was present
in existing populations to warrant attempts to breed for high-
sucrose fruit, which potentially would be less subject to bird
predation. Three-fold differences in fruit sucrose concentration
were found among species, ranging from 19 to 24 mg·(g fw)⁻¹ in *V.*
stamineum and *V. arboreum* to about 7 mg·(g fw)⁻¹ in cultivated
blueberry (*V. ashei* and *V. corymbosum*) and *V. darrowi*. Soluble
acid invertase activity was negatively correlated with fruit sucrose
concentration. There was no apparent correlation between fruit
sugar concentration and either sucrose phosphate synthase or
sucrose synthase activities, both of which were low for all species
studied. The degree of variability in fruit sucrose accumulation
among *Vaccinium* species supports the feasibility of developing
high sucrose fruit, which would be a potentially valuable addition
to current strategies of minimizing crop losses to birds.

7 4 7 PB 105
CLEISTOGAMY GENE ACTION IN SALPIGLOSSIS IS LINKED TO
SUGAR METABOLISM

Lijuan Wang*, Nian-Oine Shi, Murray E. Duysen, and Chiwon W. Lee,
Department of Crop and Weed Sciences, North Dakota State University,
Fargo, ND 58105

Cleistogamy in *Salpiglossis sinuatu* L. involves a sequence of events,
including arrested corolla development, precocious pollen germination inside
anther, pollen tube penetration of the pistil, and eventual self fertilization,
that takes place within a tightly closed flower bud. A single dominant gene
(*C*) controls cleistogamy in this plant. During early blooming period,
cleistogamous (*CC*, *Cc*) plants produce both chasmogamous (open) and
cleistogamous (closed) flowers. Enzymes in various tissues of both
cleistogamous and chasmogamous buds were detected by isozyme banding
patterns in starch gel electrophoresis. The onset of cleistogamy may be
signalled in the calyx and corolla tissues in the early stage of flower
development. The levels of specific enzymes (PGM, PGI, G-6PD, PGD,
MPI) involved in gluconeogenesis, pentose phosphate shunt and glycolysis
in both calyx and corolla tissues of the cleistogamous buds were greatly
reduced. These enzymes were present in the pistil and anthers of
cleistogamous buds and in all floral parts of the chasmogamous buds.

7 4 8 PB 108
THE RELATIONSHIP BETWEEN ROOT HAIR DEVELOPMENT AND OTHER ROOT
ATTRIBUTES IN CITRUS AND CITRUS RELATIVES

Richard J. Crawford and David M. Eissenstat, Citrus Research
and Education center, University of Florida-IFAS, 700
Experiment Station Road, Lake Alfred, Florida, 33850-2299

The relationship of genotypic variation in root hair
development with root proliferation, mycorrhizal colonization,
and specific root length (length / dry mass) was studied in
sixteen field-grown citrus relatives. The species varied
widely in hair development, root length and mass density, and
specific root length. No correlation was found between hair
development, mycorrhizal colonization, root proliferation, and
specific root length. However, there was a significant
correlation ($r=.55$) between the percentage of total root
length with hairs and the percentage of hairs with adhered
soil. In a second experiment, the phenotypic plasticity in
root hair development was studied in four-citrus rootstocks:
Swingle citsumelo, Sour orange, Trifoliate orange and Volkamer
lemon. Roots were grown in either mineral soil or high organic
matter media. After eight weeks, root length density and
percentage of root length with hairs averaged over all four
rootstocks was 232 % and 85 % greater in the organic media
than in the mineral soil. Similar to the first experiment, the
percentage of total root length with hairs was significantly
correlated ($r=.99$) with the percentage of hairs with adhered
soil.

7 4 9 PB 111
EVIDENCE FOR STRUCTURAL AND COMPOSITIONAL CHANGE IN
PHLOEM OF BLIGHT-AFFECTED CITRUS.

Kathryn C. Taylor and Xi He, Dept of Plant Sciences, University of
Arizona, Tucson, AZ 85721

Citrus blight is a decline disorder of unknown etiology. Its earliest
symptom is redistribution of Zn within the tree. The canopy exhibits
symptoms of Zn deficiency while Zn accumulates in trunk phloem just above
the bud union. Phloem Zn was associated with complexing agents. Zn-
binding proteins (ZBPs) were isolated from phloem tissue extracts of mature
healthy and blight citrus trees. After purification by ion exchange chromato-

graphy (IEC) and size exclusion chromatography, ZBP's from healthy and
blight-affected citrus trees {'Valencia' sweet orange [*Citrus sinensis* (L.)
Osbeck] on rough lemon [*C. jambhiri* (L.)]} were compared for relative
abundance. Size exclusion chromatography indicated that the proteins were
and 19.5 kD M_r. IEC demonstrated that the 5 kD ZBP was slightly anionic
and that the 19.5 kD ZBP was highly anionic. There were 2.5 x times more
of the 5 kD ZBP in blight material than in healthy (purified on an equal prot
basis). Levels 19.5 kD ZBP were equivalent in blight and healthy phloem
tissue extracts, on both fresh weight and total protein bases. The amino acid
composition of the 5 kD ZBP was much more complex than would be
expected for phytochelatin. Altered phloem structure also was apparent in
blight versus healthy trees, with phloem fresh and dry weights increased in
the blight-affected citrus. Phloem specific expression of the ZBPs was also
apparent.

7 5 0 PB 114
PARALLEL CHANGES IN AMMONIA, ARGININE AND
PUTRESCINE CONTENT AND METABOLISM IN POTASSIUM-
DEFICIENT CITRUS LIMON(L)

Yusheng Zheng and Carol J. Lovatt, Department of Botany and Plant
Sciences, University of California, Riverside, CA 92521, U.S.A.

Rough lemon seedlings [*Citrus limon* (L)] were hydroponically-
cultured in complete Shive's nutrient solution (+K) or in Shive's nutrient
solution with potassium omitted (-K) for a period of eight months. Fresh
and dry weight of whole -K plants were reduced 4-fold ($P<0.01$).
Nitrogen metabolism was monitored during this period in young, fully
expanded leaves. Results showed that leaves of -K plants accumulated
2.5-fold more $\text{NH}_3\text{-NH}_4^+$ than +K plants ($P<0.01$) and exhibited a
concomitant increase in both activity of the *de novo* arginine biosynthetic
pathway (2.5-fold) and free-arginine concentration (3.5-fold; $P<0.001$).
Leaf proline content of -K plants increased 1.6-fold ($P<0.05$), while
putrescine content increased 10-fold. Arginine decarboxylase activity was
accelerated in -K plants.

7 5 1 PB 117
ROOT AND SHOOT GROWTH PATTERNS OF 'MAURITIUS'
LYCHEE TREES

Thomas E. Marler* and L.E. Willis, 'College of Agriculture & Life
Sciences, UOG Station, Mangilao, Guam 96923; 'The Montgomery
Foundation, 11901 Old Cutler Road, Miami, FL 33156

'Mauritius' lychee (*Litchi chinensis* Sonn.) trees were planted in
root observation chambers in July 1990 to determine the pattern of root
and shoot growth during a 12 month period. Root and shoot lengths
were measured at intervals ranging from 7-18 days, from Aug. 1990 until
Aug. 1991. During each period of active canopy growth, up to six shoots
were tagged and measured. Root growth was determined by measuring
tracings the extension of each root in a visible plane from the glass wall
of the observation chambers. Shoot growth was cyclic, with distinct
periods of extension followed by no extension. Alternatively, root
growth was fairly continuous with only a few periods of no apparent
extension. There were no consistent relationships observed between root
and shoot growth patterns.

7 5 2 PB 120
TRANSPORT OF TRYPTOPHAN AND CONVERSION TO IAA
IN AVOCADO TISSUES

Isa Bertline* and Carol J. Lovatt, Department of Botany and Plant
Sciences, University of California, Riverside, CA 92521.

Tryptophan is known to be a precursor of IAA in plants. The
amount of IAA available for the development of avocado fruit might
be a limiting factor for its growth. It is well known that IAA is not
transported into developing fruit along its strictly basipetal transport
route. Therefore, IAA present in fruit must be synthesized in situ.
We investigated the possibility that tryptophan or its metabolites are
transported from leaf to fruit.

An HPLC method was developed to quantitatively isolate and
measure tryptophan and all well known intermediates in the synthesis
of IAA. Avocado leaves were fed L-[side chain-3-¹⁴C] tryptophan
and its transport and metabolism to IAA within the leaf and within the
fruit were monitored over time. Significant movement of tryptophan
or a metabolite from leaf to fruit occurs in 24 h.

POLLEN-PISTIL INCOMPATIBILITY DIFFERENCES BETWEEN MANZANILLO AND FRANTOIO OLIVE (*Olea europaea* L.) CULTIVARS

J. Cuevas, L. Rallo, H.F. Rapoport Department of Agronomy, University of Cordoba, Cordoba, Spain 14005

We have compared reproductive processes and fruit set in Manzanillo and Frantoio olive cultivars which are reported in the literature respectively as incompatible and partially compatible. The same incompatibility reaction was observed in both cultivars. Pollen tube growth was almost completely inhibited beyond the stigma, but some degree of self-fertilization was accomplished. However, in both cultivars cross-pollination provided a earlier and higher level of fertilization. Differences in self-incompatibility behavior seemed related to the level and the amount of delay in self-fertilization. In the compatible variety, Frantoio, self-pollen tube growth was accomplished more rapidly and showed a higher level of self-fertilization than in the incompatible Manzanillo cultivar. Fruit set matched reproductive behavior.

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PB 146

Physiology of Olive Leaf Abscission Induced by Phosphorus

Hisashi Yamada and George C. Martin

Department of Pomology, University of California, Davis, CA 95616

The addition of Al_2O_3 to 8-hydroxyquinoline citrate (8-HQC) solution did not alter the sensitivity of the leaf abscission zone to external ethylene treatment. Exogenous ethylene at $791\text{ nl}\cdot\text{l}^{-1}$ for 72 to 120h and at $193\text{ nl}\cdot\text{l}^{-1}$ for 120h induced leaf abscission whereas at $47\text{ nl}\cdot\text{l}^{-1}$ for 72 to 120h no leaf abscission occurred. Ethylene treatment at $791\text{ nl}\cdot\text{l}^{-1}$ for 72 to 120h increased ethylene evolution, but the amount of ethylene evolved from the explants does not seem to be enough for leaf abscission induction. Three different ethylene inhibitors, aminooxyacetic acid (AOA), $CoCl_2$ and aminoethoxyvinylglycine (AVG), were used to determine whether phosphorus-induced leaf abscission was mediated through elevated ethylene evolution. Although AOA and $CoCl_2$ failed to inhibit ethylene evolution from the explants stem-fed with NaH_2PO_4 , AVG inhibited ethylene evolution. Each of the inhibitors except for 5mM $CoCl_2$ promoted leaf abscission when administered alone or with phosphorus. Our results reveal that phosphorus induced olive leaf abscission occurs without elevated ethylene evolution, but that oxygen is required.

755

PB 149

IN VIVO POLLEN GERMINATION AND TUBE ELONGATION ON FEMALE FLOWERS IN 'SHAHANI' DATE PLAM

Asad Tavakkoli & Enayat Tafazoli*, Department of Horticulture, College of Agriculture, Shiraz University, Shiraz, Iran.

Hand pollinated pistillate date palm flowers were removed 2, 6, 10, 16, 20 hours after pollination, fixed, cleared with 8N NaOH and stained with aniline blue. The Fluoresced pollen tubes were observed under ultra violet microscope. It was noted that under natural conditions with mean temperature of 19C pollen tube reached the ovary after 16 hours.

Viability test of fresh and stored pollen grains using Brewbaker & Kwack's media at room temperature was 85 and 52.5% respectively.

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PB 152

DIURNAL PATTERNS OF SHOOT EXTENSION GROWTH IN FIELD-GROWN PEACH

Matt E. Berman and Theodore M. DeJong, Department of Pomology, University of California at Davis, Davis CA, 95616.

The primary period of shoot extension growth on field-grown peach trees occurs in the evening. Field measurements indicate a 2-3 fold increase in growth rate occurs in the late afternoon and lasts for about 2 hours. The daily growth pattern is correlated with trends in temperature, water potential and carbohydrate concentrations. Early morning and late night growth rates are apparently limited by low temperatures. Heating shoot tips at these times causes extension rate to increase greatly above that of controls at ambient temperature. The afternoon surge in extension growth rate is correlated with recovering stem water potentials. Artificially increasing stem water potential at mid-day by reducing transpiration causes extension rates to dramatically increase 2-3 fold. Starch is accumulated in the shoot extension zone during the day and depleted during the evening surge in growth.

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PB 155

LABORATORY RESPONSE TO DORMANCY-BREAKING TREATMENTS DIFFERS BY BUD AND CUTTING TYPE IN PEACH

Gil Nir*¹ and Greg Lang², Jordan Valley R&D Authority, MP Bikat Hayarden 10945, Israel¹; Horticulture Dept, Louisiana State Univ, Baton Rouge, LA 70803²

Endodormant 'Hawthorne' peach shoots were collected in early autumn and sectioned into long (30-40 cm), short terminal (10-15 cm), or short sub-terminal (10-15 cm) cuttings. Dormancy-breaking treatments included application of hydrogen cyanamide (H_2CN_2), thiourea (TU), sodium azide (NaN_3) or gibberellic acid (GA_3) solutions; atmospheric methyl jasmonate (MJ); hot water (50C for 1-2 h); or chilling (3.5C for 1-4 weeks). During forcing at 24C, & budbreak of all bud types on long cuttings was very low. On short cuttings, % apical budbreak was greater than % lateral vegetative budbreak, with almost no floral budbreak. Relative to H_2CN_2 -induced lateral vegetative budbreak, budbreak induced by MJ, TU, GA_3 , and NaN_3 was 17, 34, 50, and 92%, respectively. Relative apical budbreak was 0, 95, 53, and 63%, respectively. Addition of aminooxyacetic acid (AOA) to the beaker solution (in which cuttings were forced) induced apical, but not lateral, budbreak by itself; AOA synergistically improved H_2CN_2 -induced budbreak by 23%. Latet al budbreak on short sub-terminal cuttings treated with hot water (1 h) was similar to that of H_2CN_2 treatment. Chilling increased apical budbreak to 100% as duration increased to 3 weeks, lateral vegetative budbreak only reached 43% after 4 weeks of treatment. The use of different bud and cutting types as model systems to study the differential regulation of dormancy by various treatments will be discussed.

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PB 158

COMPARISON OF SEASONAL PATTERNS OF POLYAMINES DURING FRUIT AND SEED GROWTH OF PEACHES

Mosbah M. Kushad*, Department of Horticulture, University of Illinois, 228 PABL 1201 W. Gregory Ave. Urbana, IL 61801.

Seasonal variation in polyamines were evaluate during growth of fruit and seed of peach (*Prunus persica* L. cvs. Loring and Biscoe) starting at fruit set. In both cultivars, putrescine and spermidine increase significantly while spermine increase only slightly during the early stages of development then declined at the later stages. During pit hardening, polyamines in the flesh remained unchanged but their level in the seed continued to decrease. In both cultivars, polyamine levels corresponded to changes in fruit and seed sizes. When polyamines were vacuum infiltrated into commercially mature Biscoe fruits, flesh firmness, ethylene biosynthesis, and flesh color were significantly different from untreated tissue. The relationship between polyamines, seed development, and fruit development and ripening will be examined.

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PB 181

WATER AND HORMONAL INVOLVEMENT IN GROWTH AND DEVELOPMENT OF PEACH TREES UNDER ROOT RESTRICTION

Leonardo Alvarez and Caula A. Beyl*, Department of Plant and Soil Science, Alabama A&M University, Normal, AL 35762

A greenhouse study was established to evaluate the effect of different levels of root restriction on morphology, hydraulic conductivity, root length, and t-zeatin and dihydrozeatin riboside levels in exudate in peach trees. One-year-old 'Redhaven' peach on 'Lovell' rootstock were grown for 18 weeks in containers with volumes ranging from 1.93 to 11.55 liters. Plants grown in the most restricted containers (1.93 to 3.85 L) had roots that were smaller and exhibited fewer primary and secondary branches with less average length. Final leaf, stem, root fresh and dry weight and root length were reduced in the highly restricted versus the less restricted treatments (7.7 and 11.55 L). Root hydraulic conductivity (L_p) was not affected by container volume. There was less dihydrozeatin riboside and trans-zeatin in exudate of the most restricted plants versus the less restricted ones. Cytokinin levels continued to decrease over the time course of treatment. Shoot:root ratio was not altered by the container volume suggesting a coordination of root and shoot growth modulated by the container size.

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PB 184

INDOLE-3-ACETIC ACID REGULATES APICAL DOMINANCE BY CONTROLLING THE STATE OF WATER AND MEMBRANE LIPID COMPOSITION IN BUDS OF MALUS DOMESTICA BORKH.

Shiow Y. Wang*, Miklos Faust, and Michael J. Line
Beltsville Agricultural Research Center, Agricultural Research Service, USDA, Beltsville, MD 20705-2350

The effect of Indole-3-acetic acid (IAA) on apical dominance in apple (*Malus domestica* Borkh.) buds was examined by studying changes in proton density (free water) and membrane lipid composition in lateral buds. Decapitation induced budbreak and enhanced lateral bud growth. IAA replaced apical control of lateral bud paradormancy. Maximal inhibition was obtained when IAA was applied immediately after the apical bud was removed. Delaying this application weakens the effect of IAA. An increase in proton density in lateral buds was observable 2 days after decapitation, whereas the change in membrane lipid

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composition occurred 4 days later. Decapitating the terminal bud induced an increase in membrane galacto- and phospholipids, and the ratio of unsaturated to corresponding saturated fatty acids. Decapitation also induced a decrease in the ratio of free sterols to phospholipids in lateral buds. Application of IAA to the terminal end of decapitated shoots inhibited the increase of proton density and prevented changes in the membrane lipid composition of lateral buds.

initiation and prevented flower development, while high temperature (26C) reduced the longevity of the open flowers. Flowering was accelerated and dry weight increased as plants were subjected to high irradiance levels. The results suggest that *Lysimachia congestiflora* is a quantitative long day plant. It should be grown under a photoperiod of at least 12 hours at a temperature of approximately 20C. Low light areas should be avoided and supplemental lighting to provide the long days may improve the plant quality.

761 PB 187
DIFFERENTIAL DEVELOPMENT OF ANTHOCYANINS IN
BAGGED 'DELICIOUS' AND 'FUJI' APPLES

Eric A. Curry, USDA/ARS Tree Fruit Research Laboratory, 1104 Western Avenue, Wenatchee, WA 98801

Within red cultivars, highly colored apples are often preferred. In addition to being esthetically more appealing, better color often indicates ripeness, better tasting fruit. Anthocyanin synthesis in apples is influenced by many external factors including light, temperature, nutrition, pruning, thinning, growth regulators, and bagging. Bagging is the practice of enclosing young fruitlets in several layers of paper to promote color development after the bag is removed in the fall before harvest. In experiments related to the temperature optimum of color development in various cultivars, bagging was used to produce fruit void of anthocyanins. Double layer paper bags (black-lined outer bag, red inner bag) were placed on 'Akafu-1 Fuji', 'Oregon-Spur Delicious', and the early coloring 'Scarlet Spur Delicious' on June 21, 1993. Bags were not removed until fruit was taken to the lab on September 22 for both 'Delicious' and 'Fuji'. Whereas bagged 'Fuji' apples were without red pigment, bagged 'Delicious' sports showed considerable red pigment development, completely covering the apple in the case of the blush-type 'Scarlet Spur' and showing streaks without pigment in the snipe-type 'Oregon-Spur'.

762 PB 190
RELATIONSHIP OF PHENYLALANINE AMMONIA LYASE
AND ANTHOCYANIN SYNTHESIS IN APPLE

Zhiguo Ju, Laiyang Agricultural College, Shandong, China
Three years of experiments were carried out with both Delicious fruit on trees and fruit skin discs. There were two peaks of phenylalanine ammonia lyase (PAL) activity during fruit development. One occurred in the fruitlet stage and the other in the fruit enlargement stage. The first peak was coincident with anthocyanin synthesis in fruitlet but the second peak did not correlate with pigment formation during maturation. In fact, PAL activity decreased gradually during fruit maturation and coloration. Treatment with L- α -aminoxy-B-phenylpropionic acid, a specific PAL inhibitor, decreased PAL activity in fruit and in skin discs 57% and 80%, respectively, but did not change anthocyanin content. Cycloheximide inhibited anthocyanin synthesis by 76% in fruit and 85% in skin discs, but did not significantly inhibit PAL activity. On the other hand, PAL activity was positively correlated with concentrations of simple phenols which were direct products of PAL and precursors for synthesis of lignin, anthocyanin and other flavonoid.

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763 PB 307
ENVIRONMENTAL CONTROL ON FLOWERING AND GROWTH
OF *LYSIMACHIA CONGESTIFLORA*

Donglin Zhang*, Allan M. Armitage, James M. Affolter, Michael A. Dirr.
Department of Horticulture, University of Georgia, Athens, GA 30602.

Lysimachia congestiflora Wils. (Primulaceae) is a new crop for American nurseries and may be used as an annual in the north and a half-hardy perennial in the south. The purpose of this study was to investigate the influence of photoperiod, temperature, and irradiance on its flowering and growth. Three experiments were conducted with photoperiod of 8, 12, 16 hrs day⁻¹, temperature of 10, 18, 26C, and irradiance of 100, 200, 300 μ mol m⁻²s⁻¹, respectively. Plant 9 given long day photoperiod (16 hours) flowered 21 and 34 days earlier, respectively, than plants at 12 and 8 hour photoperiods. Plants under long day treatment produced more flowers than those at 8 and 12 hours. Plant dry weight did not differ between treatments, but plants grown in the long day treatment produced fewer but larger leaves. Total plant growth increased as temperature increased, but lower temperature (10C) decreased flower

764 PB 310
GROWTH AND FLOWERING OF *HEUCHERA* CULTIVARS.

M. L. Albrecht* and D. M. Crockett, Dept. Horticulture, Forestry and Recreation Resources, Kansas State University, Manhattan, KS 66506.

Heuchera cultivars were studied to examine the influence of photoperiod and refrigerated storage on vegetative and reproductive growth. As daylength increased from 9 to 15 hours, using day extension, petiole length and leaf area increased. Daylength during the forcing period appears to have minimal influence on reproductive growth. Forcing under 15-m daylength reduced the time to inflorescence emergence and delayed the time to anthesis of first floret and inflorescence maturity in comparison to natural daylengths or short days. Cold storage (4°C) for 14 weeks resulted in quicker inflorescence emergence than no storage or 10 weeks of storage.

765 PB 313
COLD STORAGE OF PLUG-GROWN PETUNIA AFFECTS
PHOTOPERIOD RESPONSE

Mark P. Kaczperski*, Allan M. Armitage and Pamela M. Lewis, Department of Horticulture, University of Georgia, Athens, GA 30602

Seed of *Petunia* \times *hybrida* 'Ultra White' were germinated in #406 plug trays at 2.5 C and at a light intensity of 100 μ mol s⁻¹m⁻² using a 24 or photoperiod. At germination, seedlings were grown under natural light conditions for 8 hrs (SD) or for 8 hrs with the photoperiod extended to 16 hrs (LD) using incandescent bulbs. At approximately the 6th leaf stage, seedlings were stored at 5 C in the dark or at 12 μ mol s⁻¹m⁻² and a 24 hr photoperiod for 0 to 21 days. After storage, plants were potted in 10 cm pots and grown to flowering in a greenhouse. Plants grown under SD to the 6th leaf stage with no cold treatment were shorter, flowered later and had more lateral branching than unstored LD plants. Storage at 5 C decreased time to flower of SD plants and increased branching of LD plants regardless of photoperiod during storage.

766 PB 316
INFLUENCE OF PHOTOPERIOD AND LIGHT INTENSITY ON
PLANT HEIGHT OF *LILIUM LONGIFLORUM* THUNB.

Theo J. Blom, Hort. Res. Inst. of Ontario, Vineland Station, Ont. L0R 2E0, M.J. Tsujita and Glen L. Roberts, Dept. of Horticulture, Univ. of Guelph, Guelph, Ont., N1G 2W1

Potted plants of *Lilium longiflorum* Thunb. cvs. 'Ace' and 'Nellie White' were grown either under an ambient photoperiod (APP) or under an 8-hour photoperiod (8PP) in a greenhouse. The latter photoperiod was achieved by pulling black cloth over the plants at 1615HR and removing the cloth at 0615HR each day, from emergence to flowering. Within each photoperiod, ambient light intensity was reduced by 0, 20, 40 or 60% using various shade cloths permanently suspended above the plants. Heating was set at 20/16C for the dark/light period, respectively. Plant height, determined from the rim of pot to the top of plant, was 25% lower under 8PP compared to APP for both cultivars. Plant height of 'Ace' and 'Nellie White' increased by 1.5 mm and 2.5 mm, respectively, per 1% light reduction.

767 PB 319
CONTROL OF CYCLAMEN DEVELOPMENT BY IRRADIANCE
AND TEMPERATURE

Meriam G. Karlsson* and Jan T. Hanscom, Department of Plant, Animal and Soil Sciences, University of Alaska Fairbanks, Fairbanks, AK 99775-7200

Seeds of cyclamen 'Laser Scarlet' were germinated at 20C in darkness. Four weeks after germination, the seedlings were moved to a greenhouse at 20C and 16 hours daylength and 4 weeks later transplanted into 10 cm (520 cm²) pots. Plants were grown under 8 or 16 hours daylength in combination with 3.0, 7.5 or 12.0 mol-day⁻¹m⁻² for 9 weeks after transplant. The instantaneous irradiance was adjusted

based on photoperiod to provide the desired total daily irradiance levels. After the 9 weeks photoperiod and irradiance treatment, plants were allowed to develop and flower at 16 hours daylength, 7.5 mol-day⁻¹m² (130 μ mol-s⁻¹m²) and 15C. There was a trend for an increased number of leaves for cyclamen grown at higher total daily irradiance levels at either 8 or 16 hours photoperiod. The largest number of leaves (14 \pm 2.2 leaves) after the 9 weeks was observed for cyclamens grown at 16 hours photoperiod and 12 mol-day⁻¹m² (210 μ mol-s⁻¹m²). The plants grown at the longer day length and highest irradiance level also, accumulated most dry weight (92 \pm 18.7 mg) during the 9 weeks of photoperiod and it-radiance treatment.

768

PB 389

THE INFLUENCE OF ROOT-ZONE HEAT AND NIGHT AIR TEMPERATURES ON THE PRODUCTION OF SNAPDRAGONS (*ANTIRRHINUM MAJUS* L.) GROWN FOR CUT FLOWERS.

Muhammad Maqbool* and Steven E. Newman. Department of Plant and Soil Sciences, Box 9555 Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS 39762.

Twelve snapdragon cultivars of different response groups were grown in a double polyethylene greenhouse to determine the impact of no root-zone heat (RZH) and 22C RZH at 15 or 20C night air temperature (NT) on flower quality. Data were recorded when the first floret of each stem showed color and harvested when the lower third of the florets were open. Flower quality was evaluated at harvest based upon stem length and fresh weight using Society of American Florists standards. Cultivars 'Butterfly White II', 'Hercules', 'Navajo', and West Virginia' (Group II) were the first to bloom under 20C NT regardless of RZH; whereas cultivars 'Oklahoma', 'Houston', and 'Potomac Pink' (Group IV) were delayed. Similar trends were observed under 15C NT, but the crop was harvested a few days earlier with RZH as compared to no heat. Flower quality was better under 15C NT.

769

PB 345

NUTRIENT PARTITIONING IN 'NELLIE WHITE' EASTER LILIES GROWN UNDER TWO TEMPERATURE REGIMES

Brian E. Whipker¹, Terri Kirk¹, William B. Miller² and P. Allen Hammer¹ ¹Dept. of Horticulture, 1165 Horticulture Building, Purdue University, West Lafayette, IN 47907-1165. ²Dept. of Horticulture, Clemson University, Clemson, SC 29634

'Nellie White' Easter lilies were grown under two day/night temperature regimes, a positive differential temperature (+DIF) of 15.5C night / 21C day temperature or a negative differential temperature (-DIF) of 19.4C night / 14.4C day temperature. At anthesis the plants were divided into 15 leaf-node segments, starting from the plant base (nodal position 0-15). The segments were further subdivided into leaf, stem and flower tissue parts, with fresh and dry weights being recorded, and tissue being analyzed for NH₄-N, P, K, Ca, Mg, Na, Cu, B, Fe, Mn, and Zn.

Of the elements studied, only P content was statistically different at the DIF treatment x nodal position x tissue type interaction. Total leaf P per segment was higher in the -DIF plants, with the concentration increasing from 0.19 mg at nodal position 0-15 up to the 1.34 mg at nodal position 46-60, compared to 0.16 and 0.76 mg, respectively, for the +DIF plants. There were also significant differences at the DIF treatment x tissue type, with -DIF leaf tissue having a higher total content of P, K, Mg, Ca, Na and B, while Cu was lower, than the +DIF leaf tissue. Results indicate that the distribution of nutrients in Easter lily plants are affected by growing temperature regimes.

770

PB 348

INFLUENCE OF CHILLING TEMPERATURE TREATMENT ON CARBOHYDRATE COMPOSITION AND ENDODORMANCY OF AZALEA

Camille B. Werther*, N. Suzanne Lane, and Gregory A. Lang, Department of Horticulture, Louisiana State University, Baton Rouge, LA 70803

Year-round production of the florist azalea cv. Gloria is limited by non-uniform flowering in fall-produced, endodormant-budded plants. To examine the effects of the standard dormancy-breaking chilling treatment (six weeks at 3.5 C) on carbohydrate metabolism, single-cutting plants were chilled in low light (10 μ mol-m⁻²s⁻¹) or in continuous dark. Treatment effects were studied by destructively harvesting canopy organs for dry weight and carbohydrate analysis at two week intervals during treatment and at five day intervals during greenhouse forcing. Flowering performance was also evaluated. No differences were found between the low light or continuous dark chilling treatments for canopy organ dry weights, days to initial flowering, or days to 50% flowering. Leaf dry weight decreased 22% during chilling, and did not recover to pre-treatment levels through 15 days of forcing. Stem dry weights did not change during treatment or forcing. Floral bud dry weights were maintained during treatment and increased during forcing. Analysis of soluble carbohydrates indicated that the low light treatment

influenced carbohydrate metabolism, resulting in increased concentrations of sucrose, fructose, and glucose in all canopy organs compared to the dark treatment. Maltose concentrations were higher in the light for leaves and stems, but not buds. The potential significance of these changes, with respect to dormancy-breaking treatments and uniform flowering performance, will be discussed.

771

PB 351

VARIATION IN FLORICULTURAL PERFORMANCE OF 'GLORIA' AZALEA AFTER DORMANCY-BREAKING TEMPERATURE TREATMENTS

Gloria B. McClure*, N. Suzanne Lane, and Gregory A. Lang, Department of Horticulture, Louisiana State University, Baton Rouge, LA 70803

Commercially-produced, endodormant 'Gloria' azaleas were placed into temperature x duration dormancy-breaking treatments at 2 month intervals to characterize seasonal variation in floricultural performance. Given the standard industry practice to break bud dormancy is 6 weeks at 3.5 to 7.2 C, three temperatures (3.5, 7.5, 11.5 C) and four durations (2, 4, 6, 8 weeks), plus a non-chilled control, were used to examine the contribution of each dormancy-breaking factor to subsequent floricultural quality. Treatment-induced leaf abscission and flowering were quantitated, including days to initial flowering and 50% flowering. Flowering response of dormant-budded azaleas produced during late spring and early summer (chilled during summer and early fall, respectively) was primarily and positively related to chilling duration, with only a minor influence of chilling temperature. In contrast, flowering of fall-produced endodormant plants (chilled during late fall) was best at 3.5 C, regardless of duration. Across all intervals, control plants averaged a leaf loss rate of 3 to 4 per day, suggesting a steady-state turnover rate. While leaf abscission was higher in all chilling-treated plants, those produced during fall and given the standard (or longer) chilling treatment exhibited about twice the total abscission (averaging as much as 20 leaves per day) as plants produced at other times, resulting in a clear reduction in plant foliar quality.

774

PB 360

THE RESPONSE OF IRIDON CHRYSANTHEMUMS TO DIFFERENT KINDS OF GROWTH REGULATORS

Eddie B. Williams*, William F. Hayslett and Sabrina L. Shaw, Tennessee State University, Nashville, TN 37209-1561

Growth regulators were applied on Iridon Chrysanthemums during the month of January, 1993 to determine their response. The growth regulators used were uniconazole, [(E)-(+)-(S)-1-(4-chlorophenyl)-4,4 dimethyl-2-(1,2,4-triazol-1-yl)-1-pent-ene-3-ol], daminozide [(butanedioic acid mono (2,2dimethyl hydrazide)], ancymidol [a-cyclopropyl-a-(p-methoxy-phenyl)-5-pyridinemethanol] and chlormequat* (2-chloroethyl) trimethylammonium chloride (not labeled for mums). The daminozide treated plants received a second application 14 days after the initial treatment. Peters 20-20-20 NPK water soluble all purpose fertilizer were used for all treatments.

There were significant differences in plant height, total fresh weight, total dry weight, total number of flowers, and total number of buds due to treatment. Uniconazole had the greatest effect on plant height, and the other parameters observed. Although there were differences between the uniconazole and daminozide treated plants for number of flowers and number of buds, these differences were not significant.

773

PB 357

NUTRITIONAL LEVELS OF ANTHURIUM LEAVES - MATURE VS. YOUNG LEAVES

Holly L. Scoggins-Mantero* and Harry A. Mills, Department of Horticulture, University of Georgia, Athens, GA 30602

Nutritional levels of mature vs. young leaves of Anthurium (*Anthurium andraeanum* Linden.) cultivars were determined over a seven year period. Nutritional levels for essential nutrients tested (B, C a⁺⁺, Cu⁺⁺, Fe⁺⁺, K⁺, Mg⁺⁺, Mn⁺⁺, Mo⁻, P, and Zn⁺⁺) were determined with inductively coupled plasma emission spectrometry. Kjeldahl N was determined with a flow injection analyzer. The young leaf, 90% mature, was determined to be the most accurate predictor of the nutritional status of anthuriums. These values were established for the cultivars 'Kozohara', 'Nitta Orange', 'Kaumana', and 'Ozaki'.

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PB 354

DYNAMICS OF NITROGEN PARTITIONING IN ROSES DURING A FLOWERING CYCLE

Richard Y. Evans*, Raul I. Cabrera¹, and J.L. Paul, Dept. of Environmental Horticulture, University of California, Davis, CA 95616. ¹Current address: Dept. of Plant Science, Rutgers University, New Brunswick, NJ 08903.

N uptake by greenhouse roses is out of phase with flower shoot elongation, such that N uptake is highest when shoots are not growing and lowest when shoots are elongating rapidly. Isotopically labelled ¹⁵N fertilizer was supplied at different stages of one flowering cycle to 'Royalty' rose plants growing in a static nutrient solution system to study the partitioning of re-

cently-absorbed N and the dynamics of N partitioning. After a two-day exposure, whole plants were harvested, separated into old and new leaves, stems, and roots, and analyzed for total N and ^{15}N enrichment. During rapid shoot elongation, N uptake by roots supplied 16 to 36% of shoot N demand. The remaining N came from other organs, particularly old stems and leaves. The increased N uptake later in the flowering cycle was sufficient to meet shoot N demand and replenish the N supply in old foliage and woody tissues. These organs continued to accumulate N until the subsequent bud break, when this N became available for the next cycle of flowering shoot growth.

775 PB 383
A LEACHING FRAME FOR DETERMINING MEDIA RETENTION OF DRENCH-APPLIED PLANT GROWTH REGULATORS.

Jesse R. Quarrels* and Steven E. Newman, Department of Plant and Soil Sciences, Box 9555, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS, 39762.

A leaching frame was constructed to detect residual plant growth regulators in media. The table was 0.9 x 1.8 m and designed to hold 40 10-cm diameter by 30-cm PVC cylinders. Each cylinder was cut lengthwise in half and resealed with duct tape. Rooted cuttings of 'Freedom' poinsettias were planted into each cylinder using two media combinations: 2 vermiculite: 2 peat moss: 1 pine bark and 2 vermiculite: 1 peat moss: 2 pine bark (by volume). Four growth regulator treatments were applied to the medium two weeks after transplanting: control, 0.25 mg paclobutrazol, 0.25 mg uniconazole, and 0.125 mg paclobutrazol applied as spike. After plant growth was recorded, the cylinders were removed and sliced lengthwise. Snapdragon plugs were then transplanted into the medium along the length of the cylinder to determine if any residual paclobutrazol remained. Paclobutrazol and uniconazole reduced stem length. The presence of pine bark in the media reduced the effect of the plant growth regulators.

776 PB 386
THE INFLUENCE OF FOUR COMMERCIAL GROWTH RETARDANTS ON THE GROWTH AND DEVELOPMENT FLOWERING CABBAGE AND KALE CULTIVARS

Johnny Carter* and Sauveur Mahotiére Agricultural Research Station, Fort Valley State College, Fort Valley, GA 31030

During the Fall of 1993, four commercial growth retardants (B-nine, Cycocel, A-rest and Bonzi) were compared for their effectiveness in controlling the growth and development of three ornamental cabbage cultivars (white, red and pink) and two flowering ornamental kale cultivars (frizzy red and red peacock). Two weeks after transplanting; seedling of each cultivar were sprayed with aqueous solutions of the four commercial growth retardants. Treatments for each cultivar were arranged in a randomized complete block design with 6 replications. Plant height, plant width and dry weight were the parameters used to measure growth and development. Results showed that all the growth retardants except for cycocel significantly affected growth and development without any effect on head formation and color development. Bonzi caused the greatest growth suppression.

EFFECTIVENESS OF PACLOBUTRAZOL ON HEIGHT CONTROL OF MINI-POINSETTIAS

Brian Whipker* and P. Allen Hammer, Department of Horticulture, 1165 Horticulture Building, Purdue University, West Lafayette, IN 47907-1165

Mini-poinsettias are a popular form of potted plant, but there is a need to control plant height because tall growing cultivars are used. A study was conducted to determine the suitability of paclobutrazol to control height of mini-poinsettias. Cuttings of poinsettia cultivars Freedom and Red Sails were taken on 10 Sept. 1993 and rooted under mist. On 11 Oct. when short days began, plant height was measured and 4 plant growth regulator (PGR) treatments were applied as foliar sprays using a volume of 204 ml-m⁻²: paclobutrazol at 15, 30, 45 and 60 mg-liter⁻¹, plus an untreated control. At anthesis, plant height (pot rim to top of plant) and bract diameter (measured in 2 directions and averaged) were measured. Data for plant height gain (PHG), the difference between plant height at anthesis and when PGRs were applied, and bract diameter were analyzed statistically.

PHG was significantly different at the cultivar x treatment interaction. For 'Red Sails' all paclobutrazol treatments significantly retarded PHG, but there were no significant differences in PHG with increased rates of application. For 'Freedom' only paclobutrazol rates at 30 and 45 mg-liter⁻¹ significantly retarded PHG. Bract diameter was significantly different at paclobutrazol rates 30 mg-liter⁻¹ or greater, with diameter decreasing as the rate of PGR applied increased

778 PB 392
AXILLARY BUD DEVELOPMENT OF 'RED SAILS' POINSETTIA IS INHIBITED BY HIGH DAY TEMPERATURES

James E. Faust* and Royal D. Heins, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

Poor lateral branching sometimes occurs when certain poinsettia (*Euphorbia pulcherrima*) cultivars are pinched. Two experiments were conducted to determine the effect of high temperatures on axillary bud development. In Expt. 1, 'Red Sails' plants were grown in a high-temperature environment (HTE) of 27°C at night (8 hr) and 30°C (3 hr), 33°C (10 hr), and 30°C (3 hr) in the day for two months, then transferred to a 20°C environment. In Expt. 2, plants grown at 20°C were transferred into the same HTE described above for 0, 2, 4, 8, 16, or 32 days and were then moved back into the 20°C environment. Axillary buds were examined for viability at the end of each experiment. In Expt. 1, only 8% of the lateral buds forming in the HTE were viable, while 80% of the buds forming in leaf axils of leaves unfolding after the plants were transferred to the 20°C environment were viable. In Expt. 2, 80% of buds produced in axils of the first four leaves to unfold after the start of the experiment were viable in all the treatments. However, the percentage of viable buds in the axils of leaf numbers 5 to 8 was 100, 100, 100, 96, 56, and 0 for the plants placed in the HTE for 0, 2, 4, 8, 16, and 32 days, respectively. These data indicate day temperatures of 30 to 33°C adversely affect lateral shoot development of 'Red Sails' poinsettia.

779 PB 395
PULSING TEMPERATURES AND SYRINGING AT SUNRISE REDUCE STEM ELONGATION OF EASTER LILY

James E. Faust*, Sven Verlinden, and Royal D. Heins, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

Rapid reduction in temperature for two to three hours starting at sunrise reduces stem elongation compared to elongation of plants maintained under constant temperatures during the day. This experiment was designed to determine if syringing plants with water at sunrise would substitute for a reduction in air temperature or enhance the response to the drop in temperature. Easter lily (*Lilium longiflorum* Thumb.) plants were exposed to constant 20°C or to 20°C and then 16°C for a 3-hr period following sunrise. Half the plants in each temperature regime were syringed at 30-minute intervals with 20°C water for 3 hr starting 20 minutes before sunrise. Shoot-tip temperature during the three-hr pulse time averaged 20.0 and 17.3°C for the dry plants and 17.3 and 14.7°C for the syringed plants. Total elongation for the dry plants at 20°C was 30 cm and for the temperature-pulsed plants, 4.8 cm less; for the syringed plants, 3.3 and 5.8 cm less, respectively. While shoot-tip temperature of dry plants averaged 0.9°C above air temperature during the remaining hours of the day, syringed plants averaged 1.0°C cooler than the same air temperature even though plants had dried. The data indicate the reduction in stem elongation from a low-temperature pulse at sunrise can be enhanced by evaporative cooling.

780 PB 398
BENZYLADENINE UPTAKE AND ENDOGENOUS FREE IAA LEVELS DURING SHOOT INDUCTION IN CYMBIDIUM cv. YUH HWA RHIZOMES

I-lun Lu¹*, David W. Burger¹ and Ellen G. Sutter², ¹Department of Environmental Horticulture and ²Department of Pomology, University of California, Davis, CA 95616

Long term exposure to high benzyladenine (BA) concentrations inhibited shoot elongation and root growth of *Cymbidium* cv. Yuh Hwa rhizome explants. Through transfer experiments, it was determined that the commitment to shoot induction occurred between 10 and 14 days of exposure to at least 2.5 µM BA. BA when supplied at 20 µM during the fit 14 days of culture was found to be sufficient to induce shoot formation. Both shoot elongation and root formation were greatly improved by decreasing the BA concentration. By using radiolabelled BA, adenine was found to be a major metabolite in the rhizome tissue. Free IAA levels, quantitated by GC-MS, did not correlate well with the organogenesis of rhizomes, nor did the levels of free IAA correlate well with the activities of peroxidase and IAA oxidase, indicating a complex relationship between hormone concentration and differentiation.

781 PB 421
RAPID ANALYSIS OF CARBOHYDRATE CONCENTRATIONS IN MARIGOLD LEAF TISSUE USING NEAR INFRARED REFLECTANCE SPECTROPHOTOMETRY

Guoqiang Hou* and Jack W. Buxton, Department of Horticulture and Landscape Architecture and Michael Collins, Department of Agronomy, University of Kentucky, Lexington, KY 40546

Studies were conducted to determine if near infrared reflectance spectrophotometry (NIR) could be used to rapidly determine nonstructural carbohydrate (TNC) concentrations in marigold tissue. Marigold seedlings

were grown in natural light growth chambers. Light intensity and CO₂ concentration were adjusted to establish leaf samples with a wide range of the carbohydrate concentration. NIR spectra were collected on dry, ground samples using a reflectance scanning monochromator. Conventional laboratory analysis values for the same samples were correlated with spectral data. Calibration statistics were as follows: TNC; standard error of calibration (SEC)= 1.73, R²= 0.95, standard error of prediction or performance (SEP) = 1.64, R²= 0.95; Starch, SEC = 1.35, R²= 0.96, SEP = 1.37, R²= 0.94; Soluble Sugars, SEC = 0.26, R²= 0.91, SEP = 0.29, R²= 0.84. These results show that the NIR method can be used to rapidly determine concentrations of nonstructural carbohydrates in marigold leaf tissue and suggest the possibility for routine assessment of carbohydrate status for optimum management of environmental factors.

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PB 424

INVERTASE ACTIVITY AND CARBOHYDRATE COMPOSITION IN DEVELOPING *ANTIRRHINUM MAJUS* L. FLOWERS Ricardo Campos and William B. Miller*, Department of Horticulture, Clemson University, Clemson, SC 29634.

The relationship between the activity of soluble acid invertase and metabolism of soluble carbohydrates was investigated in snapdragon flowers. Flowers were harvested at three different developmental stages, and at four different dates. Soluble carbohydrates were extracted and analyzed by HPLC; invertase activity was determined in crude enzyme extracts. Sucrose concentration slowly increased throughout flower development from a closed bud to a fully open flower. Fructose and glucose concentration were relatively lower at the bud stage, increased during petal elongation, then slightly decreased at flower maturity. Mannitol concentration showed little change during flower development. An unknown compound increased in concentration during petal elongation and decreased at maturity. For all harvest dates, the specific activity of acid invertase increased with flower development. These results show a positive correlation of invertase activity and hexose sugars accumulation. It is possible that at maturity sugars are metabolized at a faster rate than produced, causing a slight decline in hexose sugars.

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PB 427

LEATHERLEAF FERN DAMAGE AND BENLATE USE

David N. Sasseville,* Robert J. Kremer, Wm. Alan Bergfield, and Thourava Souissi Lincoln University of Missouri, Jefferson City, USDA-ARS and University of Missouri, Columbia

Benlate 50 DF has been implicated in causing long term damage to leatherleaf ferns. Damage to leatherleaf fern including frond distortion, discoloration and growth suppression continues to occur even after two or more years following last Benlate application. Electron micrographs of affected plants roots indicate a loss of root hairs and a proliferation of associated soil bacteria on the root surface compared to healthy plants. Plants with history of continued Benlate application have extensive bacterial colonies embedded on the root surface, but these colonies were not parasitic. Leatherleaf fern plants which only had their rhizomes dipped in Benlate at planting lacked the embedded colonies, but were extensively covered with bacteria. Bioassays of bacteria taken from the rhizoplane and rhizosphere of these leatherleaf ferns showed that these bacteria have the ability to produce growth regulators and/or toxins which may be detrimental to plant growth when absorbed through the root. Consequently, Benlate may be influencing fern growth indirectly by modifying bacteria composition of the growing media to favor proliferation of deleterious, non-parasitic bacteria.

784

PB 430

NONCONTACT GROWTH ANALYSIS USING 3-D IMAGE PROCESSING

Hiroshi Shimizu and Royal D. Heins,* Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

A computer vision system for noncontact growth analysis was developed. Front and side images of a plant were captured simultaneously using a mirror system and CCD camera and were magnetically stored on a magneto-optical disk. Images acquired at night were obtained by irradiating plants with incandescent light filtered to wavelengths of 850 nm and greater. Images were automatically captured and saved every 12 minutes. After images were collected, outlines of plant shape were extracted from stored images, a three-dimensional center line of the plant was extracted from the outline, and the elongation rate was computed. The outline extraction algorithm was modified to improve spatial resolution of images, and the thinning algorithm created a representative line of the plant by calculating a center line of the stem so the three-dimensional length could be calculated. Results of growth analysis on *Verbena bonariensis* L. plants grown under three photoperiods (8, 12, and 16 hours) and three day/night air-temperature combinations (15/25, 20/20, and 25/15) will be presented.

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PB 433

VALIDATION OF A ROSE SHOOT DEVELOPMENTAL MODEL

C.C. Pasian* and H.J. Lieth. Envir. Hort. Dept., University of California, Davis, CA 95616.

Temperature effects on the rate of flowering rose shoot development were previously modeled using a thermal units (heat units) approach. The current objective was to validate this model for three rose cultivars and to determine its suitability for use in rose production. Flowering shoots of 'Cara Mia', 'Royalty', and 'Sonia' plants, grown in greenhouses at three temperature settings, were observed daily to determine when each of the following developmental events occurred: "harvest", "bud break", "unfolding of each leaf", "visible flower bud", and "shoot ready for harvest". Each stage was defined to facilitate accurate, repeatable observations. Average hourly air temperatures were used in computing the accumulated thermal units (TU) required for shoots to develop from one stage to the next. The base temperature (used in the TU computation) did not differ significantly among the cultivars; the value of 5.2C was used. Using these to predict the days on which the shoot was ready for harvest resulted in ± 2 day accuracy for most shoots of 'Royalty' and 'Sonia' and ± 2.5 days accuracy for most 'Cara Mia' shoots. This indicates that this method is suitable for timing of rose crops and deciding on temperature set-points.

786

PB 436

COMPARING ROSE RESPONSES TO VARIOUS ENVIRONMENTS USING THE ROSESIM COMPUTER GROWTH MODEL

Douglas A. Hopper*, Troy T. Meinke, and Virginia S. Store, Department of Horticulture, Colorado State University, Fort Collins, CO 80523

The computer simulation model ROSESIM is based on 'Royalty' rose (*Rosa hybrida* L.) growth response to 15 unique treatment combinations of photosynthetic photon flux (PPF), day temperature (DT), and night temperature (NT) under constant growth chamber conditions. Environmental factors are assumed constant over an entire day, but set points may vary over the duration of the crop. Anticipated values for factors may be read from an ASCII file, allowing a variety of strategies to be modeled and compared.

A Valentine's Day crop scenario compared 2 management strategies for crop development time and flower quality: [1] constant 24/17.1 DT/NT for the entire crop, or [2] 15 days warm 30/20C DT/NT to promote bud break, 10 days 20/15C DT/NT to promote stem caliper and leaf size, 10 days 25/18C DT/NT to promote bud development, and remaining time to flower 20/15C DT/NT to enhance flower size and color. PPF was increased gradually over crop time as would occur naturally for Dec. to Feb. Strategy [2] had longer stems (63 vs. 50 cm), similar stem and leaf dry weights, but less flower bud dry weight (1.0 vs. 1.6 g), while flowering 2 days earlier (41 vs. 43 days after pinch).
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787

PB 439

A MUTATION ALTERING AUXIN HOMEOSTASIS AND PLANT MORPHOLOGY IN *ARABIDOPSIS THALIANA* L. HEYNH.

Joseph J. King* and Dennis P. Stimart, Department of Horticulture, University of Wisconsin, Madison, WI 53706-1590

In an attempt to analyze genetically the interaction of endogenous auxin concentration and adventitious root formation, an EMS mutagenized M₁ population of *Arabidopsis thaliana* was screened for mutants with altered abilities to form adventitious roots. A selected recessive nuclear mutant, *rooty* (*rtv*), is characterized by extreme proliferation of roots, inhibition of shoot development and other morphological alterations suggestive of auxin or ethylene effects. The *rtv* phenotype occurs in wild type seedlings grown on auxin containing medium and relatively normal growth is stimulated in *rtv* seedlings growing on cytokinin containing medium. Analysis by GC-MS found that endogenous IAA concentrations in *rtv* are 2 to 17 times higher than in wild type depending on tissue type and IAA form. Dose response experiments with IAA and NAA indicated that *rtv* does not express increased sensitivity to auxin. These data suggest that the *rtv* phenotype is due to elevated endogenous auxin. A genetic map location for *rtv* and possible roles for the wild type *RTY* gene product in regulating auxin concentration will be presented.

545

134 POSTER SESSION 19 (Abstr. 788-809) Grapes

791

PB 033

INFLUENCE OF GIBBERELIC ACID ON SIZING OF THOMPSON SEEDLESS TABLE GRAPES IN SOUTHWEST ARIZONA
Marvin D. Butler* and Robert E. Rush, Central Oregon Agricultural Research Center, 850 N.W. Dogwood Lane, Madras, OR 97741 and Yuma Agricultural Center, 6425 W. 8th Street, Yuma, AZ 85364

Early berry maturity with adequate size and sugar is a high priority for table grape producers in the desert southwest trying to capture the early fresh market, when prices are historically at their highest. Application of gibberellic acid is used, in combination with girdling to increase berry size. Research was conducted at Valley Grapes near Dateland, AZ on 1.5 hectare unreplicated plots in 1987 and 1988, and 0.2 hectare plots replicated four times in 1989 and 1990. The influence of 120g/h, 160g/h and 200g/h of gibberellic acid, applied two to three times in various combinations, was evaluated on Thompson seedless grapes. Preharvest samples provided berry weight and soluble solids data. Yield and quality were determined from the number and grade of 10 kilogram boxes harvested for each pick. Berry weight tended to increase with increased rates of gibberellic acid while yield and quality were highest for more moderate rates. Three applications generally out-performed two applications with the same, or similar, total amount of gibberellic acid.

792

PB 036

EFFECT OF ROOTSTOCKS ON SHOOTGROWTH, BERRY QUALITY, AND YIELD OF 'FUJIMINORI' GRAPES TREATED WITH GIBBERELIC ACID

Kubota N.*, Takigawa H., Ri X., and Yasui K., Faculty of Agriculture, Okayama University, Tsushima, Okayama 700, Japan

Shoot and berry growth, sugar, titratable acidity, and anthocyanin contents of berries and crop yields of "Fujiminori" grapes (*Vitis vinifera* x *V. labruscana*) were determined in vines grafted to 10 different rootstocks: 3309, 3306, 101-14, 5BB, 5C, 8B, SO4, and 420A. Three-year-old vines of 5BB stock and S-year-old vines of each of the other stocks grown in an unheated plastic house were used for this investigation.

Shoot growth was more vigorous on vines grafted to 5BB compared to 3309, SO4, and 8B. The highest yield per unit area was observed in vines grafted to 3306, followed in order by 5BB, 3309, 101-14, SO4, 5C, 8B, and 420A. The largest berry size was observed in vines grafted to 3306, followed by 5BB, 101-14, 3309, 8B, 5C, SO4, and 420A. Berries of vines grafted to 420A and 5BB had the highest total soluble solids, followed in descending order by 8B, 101-14, and 5C. Titratable acidity of berry juice was lowest in vines grafted to 420A. The anthocyanin content of berry skin was higher in vines grafted to 420A and 101-14 than in berries of other stocks. GA-treatment did not increase the percentage of seedless berries of this cultivar to a commercially acceptable level for any of the rootstocks used.

793

PB 039

CALCIUM, MAGNESIUM, AND NITROGEN FERTILIZATION AFFECTS LEAF NUTRIENT CONTENT AND GROWTH OF 'STERLING' MUSCADINE GRAPE
James M. Spiers* and John H. Braswell, USDA-ARS, Small Fruit Research Station, P. O. Box 287, Poplarville, MS 39470 and Mississippi Cooperative Extension Service, P. O. Box 193, Poplarville, MS 39470

The effects of varying N, Ca, and Mg fertilization levels on plant growth and leaf elemental content of 'Sterling' muscadine grapes (*Vitis rotundifolia* Michaux) were studied in a 2 year sand culture experiment. Increased N levels reduced leaf K, Ca, and Mn and increased leaf N and P concentrations plus plant growth. Calcium fertilization increased leaf Ca, decreased leaf Mg, but did not affect plant growth. Mg fertilization reduced leaf K and Ca and increased leaf Mg plus plant growth. Visual symptoms, assumed to be Mg deficiencies, were decreased by Mg fertilization and highly correlated to leaf Mg content. Plants which received the highest Ca fertilizer level had fewer deficiency symptoms when treated with the highest rate of N. Calcium fertilization tended to slow both Mg uptake and deficiency symptoms reductions caused by increases in levels of applied Mg. Growth of 'Sterling' muscadine plants was positively correlated to leaf N and Mg and negatively related to leaf K, Ca, Mn, Zn, and Cu concentrations.

788

PB 024

RELATIONSHIP BETWEEN WINTER BUD CONSTRUCTION AND FLOWER AND FRUIT NUMBER IN 'CONCORD' AND 'NIAGARA' GRAPEVINES
Martin C. Goffinet*, Alan N Lakso and Mary Jean Welsch, Dept. Horticultural Sciences, NY State Agric. Exper. Sta., Geneva, NY 14456

Winter buds of 'Concord' and 'Niagara' grapevines were dissected and their embryonic clusters scored to developmental stage. Stage was regressed against flower and fruit number per cluster the following year to see if flowering or fruiting potential could be gauged from bud morphology. 'Concord' vines were either minimal-pruned (MP) or balance-pruned (BP) and non-irrigated or provided supplemental irrigation. 'Niagara' vines were BP vines which were non-irrigated, irrigated, or nitrogen fertigated. Winter buds of MP 'Concord' were significantly less developed than buds of BP vines, and flower and fruit number per cluster also significantly less. Irrigation did not affect bud construction or flower or fruit number per cluster in either pruning regime. Winter buds of 'Niagara' had similar cluster stages in all treatments and there were similar flower and fruit number per cluster the following season. Within cultivar and year, there was a positive linear relationship between mean flower number or fruit number per cluster and mean stage of cluster differentiation within buds the previous dormant period. In 'Concord', a given winter cluster stage allowed production of significantly more flowers and fruit in 1992 than it did in 1993. A bud's flowering potential thus varies from year to year and depends on factors not solely related to bud morphology.

789

PB 027

SPLITTING HYDROGEN CYANAMIDE APPLICATIONS IMPROVE BUDBREAK UNIFORMITY OF 'PERLETTE' GRAPEVINES

Jorge Siller-Cepeda*, Manuel Báez, Alfonso Stichez, Alfonso A. Gardea, and Guadalupe Osorio. C.I.A.D., A.C. and CIANO. Apdo. Postal 1735, Hermosillo, Sonora. 83000, México. CIAD/DTAOV/RC/94/006.

Crop uniformity is critical in early season table grapes, because it diminishes labor and improves chances to attain high prices. Single cyanamide applications are regularly used; however, harvest still requires several pickings. On 6 Dec. hydrogen cyanamide was applied to 4 year-old 'Perlette' vines right after pruning or at different timings to advance and uniform harvest. Three rates (4, 6, and 8% Dormex) were applied as single or splitted applications. The later were made after 6, 12, 18, 24, and 48 hrs following the initial spray. The respective half rates were used in splitted applications. Our results showed that budbreak response to a single dose was 39, 71 and 93% for increasing dosages, nonetheless, buds broke unevenly. Divided rates improved both total budbreak and uniform development. However, timing between sprays also influenced the above characteristics. The best timing between applications was 6 hrs improving budbreak to 70, 75, and 100% for increasing concentrations. Since mostly primary buds broke, this also resulted in increased clusters per vine. Budbreak rates were significantly reduced when the second application was delayed by 48 hrs (30, 33, and 63% in the same order).

790

PB 030

EVAPORATIVE COOLING AND PRUNING DATE AFFECT REST DEPTH AND BREAK OF PRIMARY BUDS IN 'FLAME SEEDLESS' GRAPEVINES

Guadalupe Osorio-Acosta* and Jorge Siller-Cepeda. CIANO, INIFAP and CIAD, A.C. Apartado Postal 1735, Hermosillo, Sonora. 83000, Mexico. CIAD/DTAOV/RC/94/004.

Table grapes growing under desert conditions present a short and shallow rest mainly due to low chilling and high daily temperatures. Results using Evaporative Cooling (EC) have shown that rest is modified, and the opening of primary buds and number of clusters per plant depended on pruning date and cyanamide rate. From Oct 26 until Dec 30, rest depth was assessed under lab conditions on 'Flame Seedless' canes from EC-treated and control vines. We found that rest depth was shallow and final budbreak was higher in EC-treated plants at all sampling dates. However, hydrogen cyanamide treated canes under both conditions showed no difference on final budbreak, although the opening of primary buds was higher on the EC-treated plants. Field trials were established to quantify the effect of pruning date associated with those treatments (EC and Control) on the number of clusters per plant. Plants were pruned on Dec 14, Dec 22, and Dec 30, and cyanamide (5% Dormex) was applied immediately. Plants under EC conditions and pruned on the earliest dates enhanced the number of cluster per vine by 40 and 21.7% respectively, as compared with control plants.

5 4 6

THE ROLE OF PHOSPHORUS IN MAGNESIUM TRANS LOCATION IN MUSCADINES

Creighton L. Gunton* and James M. Spiers, USDA-ARS Small Fruit Research Station. P. O. Box 287. Ponlarville. MS 39470

The role of phosphorus (P) in magnesium (Mg) translocation from roots to leaves of muscadines (*Vitis rotundifolia* Michx.) was investigated in shadehouse experiments. Vines of 13 clones were grown for two seasons in sand culture fertilized with nutrient solutions containing no P (-P), 20 PPM P (+P), and -P plus P added during the two weeks before harvest (-P+P). Leaves were sampled at the end of each growing season and in July of the second year and analyzed for P, potassium (K), and Mg content. Mg and K contents of roots were determined at the end of the second year. No interactions occurred between clones and P fertilization levels for Mg or K content, indicating no differences among clones in response of these minerals to P treatments. Leaf Mg content was slightly but significantly lower for -P than +P treatments in the '92 and July '93 samples but about the same in September '93. Root Mg content in September '93 was higher for +P than -P or -P+P. No evidence was found that Mg translocation from root to leaves was mediated by P. No Mg deficiency symptoms were visible on the leaves for any treatment.

795

PB 065

MEASUREMENT OF INCIDENT LIGHT ON GRAPE CLUSTERS USING PHOTO-SENSITIVE PAPER AND IMAGE ANALYSIS.

Steven F. Price, Marc L. Schuette, and Elizabeth Tassie Department of Horticulture, Oregon State University, Corvallis OR 97331

Digital imaging and analysis was used to quantify and characterize the light exposure patterns of photo-sensitive paper tubes placed in representative cluster positions in two grape (*Vitis vinifera* L.) canopies: a minimally pruned and a vertically trained canopy. Blue pixel values of the captured video images had a strong negative correlation with the log of irradiance from an integrating quantum sensor ($R^2=0.9308$). Histograms of incident light distribution on individual paper tubes were developed using imaging software. Histograms were able to quantify the spatial distribution of light on individual tubes and were clearly related to exposure in the canopy. Average population curves of light distribution were able to differentiate the typical cluster light environment in the two canopies. Tubes in the minimally pruned canopy had a larger proportion of their surface exposed to irradiances greater than $50 \mu\text{mol s}^{-1}\text{m}^{-2}$ and 65% higher average irradiance than the vertical canopy. Image analysis of photo-sensitive paper appears to be a workable method to record variation in spatial and temporal light in plant canopies.

796

PB 068

STOMATAL FUNCTION OF IN VITRO GRAPE PLANTLETS TREATED WITH AND WITHOUT POLYETHYLENE GLYCOL

Masooma Ali-Abmad, Dept. of Botany, University of Baluchistan, Quetta, Pakistan and Harrison Hughes*, Dept. of Horticulture, Colorado State University, Fort Collins, CO 80523

Scanning electron microscopy was used to study stomatal function of grape (*Vitis* sp. 'Valiant') plantlets grown in vitro, polyethylene glycol-treated (PEG) in vitro and greenhouse. Fully open stomata were observed in in vitro grown plants with large aperture ($13.5 \mu\text{m}$) as compared to narrow stomatal opening and small aperture in PEG-treated ($4.9 \mu\text{m}$) and greenhouse grown plants ($3.2 \mu\text{m}$). Furthermore, stomates of persistent leaves initiated during in vitro culture remained fully open with large apertures ($12.8 \mu\text{m}$) two weeks after transplanting in the greenhouse. In contrast, newly-formed leaves produced in the greenhouse from in vitro cultured plants showed narrow stomatal opening with small apertures ($3.3 \mu\text{m}$). In vitro produced leaves exhibited rapid wilting followed by irreversible tissue damage and severe desiccation within three hours of transplantation into the greenhouse. However, PEG-treated plantlets showed a reduced stomatal opening with associated minimal stress when directly transferred into the greenhouse. Thus use of an osmotic agent, PEG, induced more normal stomatal function as well as improved survival after transfer to the greenhouse.

797

PB 071

THYLAKOID THERMOSTABILIN OF WINE GRAPES

Sorkel Kadir* and Robert Wample. Washington State University, Mount Vernon Research Unit, Mount Vernon, WA 98273, Irrigated Agriculture Research and Extension Center, Prosser, WA 99350.

Evaluation of thermostability of photosynthetic apparatus of intact leaves and isolated thylakoids of five cultivars of wine grapes (*Vitis vinifera*) was conducted. Four-week-old plants of Semillon, Chenin Blanc, Pinot Noir, Chardonnay, and White Riesling, were placed into a control environment chamber held at 20/15° 30/25°, and 40/35° C day/night

temperature for 14 days. Induced (F0), variable (Fv), and maximum fluorescence (Fm) and the quantum yield of net photosynthesis (Fv/Fm) were measured after 1-14 days exposure. All fluorescence parameters were not affected by 20/15° and 30/25°C. However, high temperature (40/35°C) increased F0 and decreased Fm, Fv, and Fv/Fm. These changes were severe in Semillon and Chenin Blanc, moderate in Chardonnay and White Riesling and scarce in Pinot Noir. Average high temperature data that are experienced in Yakima Valley area will be presented. Isolated thylakoid membranes from the cultivars were heated at 20-40°C. and uncoupled electron transport was determined. Thylakoid stability to heating varied similarly to whole-plant response to high temperature.

798

PB 074

CHANGES IN WEED SPECIES WITH DIFFERENT COVER CROPS IN TWO CALIFORNIA VINEYARDS

Clyde L. Elmore*, Scott Steinmaus, and Dean Donaldson, University of California, Davis and Napa Ca. Section of Plant Biology, Davis, CA 95616

Cover crops are grown in vineyards for many reasons, including erosion control, maintaining organic matter and changing pest complexes. Changing a management practice from using resident vegetation as a cover to other planted cover crops will change the vineyard floor flora. The cover crops of 'Olge' oat, 'Olge' oat and purple vetch, and purple vetch alone were compared to resident vegetation as winter planted cover crops. The cover was harvested in April of each year and blown under the vine row; The cover crop remains were disked into the middles after mulching. Three varieties of subterranean clover were planted in the vine rows at each location in one-half of each of the cover crops. The winter annual weed species, black and wild mustard, common chickweed and annual bluegrass decreased in the inter-row areas. The perennial weed field bindweed increased in all cover crop treatments.

799

PB 077

SUSCEPTIBILITY OF AMERICAN, EUROPEAN, AND INTERSPECIFIC HYBRID GRAPE CULTIVARS TO THE FUNGUS SEPTORIA AMPELINA

James K. Mitchell*, W. Keith Patterson* and Robert H. Ford*,

*Department of Biology, Ball State University, Muncie, IN 47306 and *Department of Horticulture & Forestry, University of Arkansas, Fayetteville, AR 72701

European *Vitis vinifera* L. (four cultivars); interspecific hybrid (seven cultivars); and American *V. aestivalis* Michx. (one cultivar), *V. labrusca* L. (three cultivars), and *V. rotundifolia* Michx. (two cultivars) grapevines were tested for susceptibility to Septoria leaf spot disease. *V. rotundifolia* cultivars Cowart and Fry exhibited hypersensitive-type resistance. All other American, European, and hybrid cultivars tested were susceptible with varying levels of disease severity. Cultivars with little (e.g. interspecific hybrid) or no (e.g. European) *V. labrusca* L. heritage were more susceptible to Septoria leaf spot than American *V. labrusca* cultivars.

800

PB 080

IMPROVED DOWNY MILDEW CONTROL IN WINE GRAPES WITH VOSSEN BLUE

Gary C. Pavlis* and Joseph A. Fiola, Rutgers Fruit R&D Center, Cream Ridge, New Jersey, 08514

Downy Mildew, *Plasmopara viticola*, causes major damage and economic loss to many wine grape cultivars grown in the Northeast. The purpose of this experiment was to test the efficacy of Vossen Blue (VB; iron pigment) in association with fungicides for the control of Downy Mildew disease of wine grapes in New Jersey. The experimental plot was a planting of Chancellor (10th leaf). Treatments (applied via back-pack sprayer) included no fungicide (NF), full fungicide (FF) (RCE commercial recs. half fungicide (HF), FF + 8% VB (FF8), HF + 8% VB (HF8), 88VB. Subjective (1-9) disease score for leaf tissue showed no statistical difference between the FF, FF8, HF and HF8 treatments however all showed superior Downy Mildew control to the 8% VB and the no fungicide control. Yield data indicated that the FF8 treatment resulted in higher yield ($p \leq 0.01$) than FF, HF and HF8. The NF and 8VB treatments resulted in the lowest yield. Compared to normal full fungicide, superior Downy Mildew control on the fruit was achieved by adding VB to full fungicide. These results are consistent with previous experiments conducted on Seyval Blanc.

BIOLOGY OF GRAPE PHYLLOXERA IN OREGON

Anne E. Connelly*, Bernadine C. Strik¹, Jeffrey Granett², and Glenn Fisher³ ¹Department of Horticulture, Oregon State Univ., ALS 4017, Corvallis, OR 97331. ²Entomology Dept., Univ. of California, Davis, CA 95616. ³Dept. of Entomology, OSU, Cordley Hall 2046, Corvallis, OR 97331.

Grape phylloxera (*Daktulosphaira vitifoliae* Fitch) was studied in three infested, self-rooted, European wine grape (*Vitis vinifera* L.) vineyards in western Oregon. Bi-weekly sampling of infested roots at two depths (15-30 cm and 30-45 cm) was done during the growing season in 1992 and 1993. Centrifuged laboratory extractions of insects were separated into life stages and counted. Results indicate hibernants emerged in April/May when soil temperatures varied from 8 to 21°C. Viable eggs were recovered in June/July. Alates and above ground crawlers were found on sticky trunk wraps in July/August. It appears there were three generations of phylloxera with the third being significantly smaller. Replicated laboratory colonies were reared at 5 temperatures (7, 10, 13, 16, 21 °C). Reproductive rates will be contrasted with field populations.

802

PB 106

PLANT REGENERATION THROUGH SOMATIC EMBRYOGENESIS AND ORGANOGENESIS IN GRAPE ROOT STOCK CULTIVAR AXR#1

Don Waneck*, H. Mathews, J. Stamp and R. Bestwick
Agrilope Inc, 8505 SW Creekside Pl, Beaverton. OR 97005

Zygotic embryo explants of grape cultivar AXR#1 were isolated from maw-e seeds and cultured on medium supplemented with naphthoxy acetic acid beta-(NOA) and benzylaminopurine (BA). Embryo explants dedifferentiated to form embryogenic callus. Globular stage embryos were visible in 9-10 months. On transfer to a growth regulator free medium supplemented with charcoal these globular embryos underwent further stages of embryo development. In a period of 30-40 days embryogenic tissues turned into clumps of somatic embryos displaying different stages of development. Cotyledonary stage embryos were separated and transferred to basal medium. These embryos developed into complete plants. Cold and desiccation treatment of somatic embryos significantly enhanced the rate of plant conversion. Hypocotyl segments of elongated somatic embryos were good source explant for induction of shoot organogenesis. The hypocotyl-length and the proximity to-shoot-apex were found to influence the rate of shoot induction from hypocotyl segments. Multiple shoot complexes which formed on hypocotyl segments were separated and individual shoots were grown on a root induction medium resulting in complete plant development. The possibility of both embryogenic and organogenic modes of plant regeneration make somatic embryos a highly versatile explant source for experiments on genetic manipulation.

803

PB 109

EFFECTS OF NAA, 2,4-D, AND BAP ON CALLUS FORMATION IN TABLE GRAPES AS INFLUENCED BY SPECIES COMPOSITION

Maurus V. Brown*, James N. Moore, and Fens H. Huang, Department of Horticulture and Forestry, University of Arkansas, Fayetteville, AR 72701
'Saturn', 'Mars', and 'Reliance' were compared based on their different *Vitis vinifera* and *V. labrusca* compositions. Disks (10 mm) from young leaves were placed abaxial side down on a standard media containing NAA or 2,4-D at 0.0, 1.0, and 2.0 mg/L with BAP at 0.0, 0.1, and 0.2 mg/L. Each treatment was replicated in 10 culture tubes and incubated at 25 ± 1°C under cool-white fluorescent light for 10h photoperiods. Calli were compared by size, color, and occurrence of morphogenesis. NAA generally produced a larger callus by cultivar than 2,4-D. A greater quantity of callus was generally produced with the increase of the *V. labrusca* component. Callus produced on 2,4-D medium was round, compact and light to dark green in color. However, callus produced on NAA medium was amorphous, friable, and ranged in colors. Rooting occurred on some calli produced on NAA media.

804

PB112

INFLUENCE OF CULTURE CONTAINER ON IN VITRO SHOOT PRODUCTION AND CALLUS FORMATION OF MUSCADINE GRAPE

Carol D. Robacker*, Dept. of Horticulture, Georgia Station, Griffin, GA 30223

Nodes from in vitro grown shoots of 'Regale' and 'Triumph' muscadine grape (*Vitis rotundifolia*) were cultured in 25 × 95-mm glass vials, 25 × 150-mm glass culture tubes, 55 × 70-mm glass baby

food jars and 100 × 25-mm plastic petri dishes. Culture medium consisted of Murashige and Skoog salts and vitamins, 80 mg/l adenine sulphate, 170 mg/l sodium phosphate, 2 mg/l BA and 8 g/l agar. Amount of medium dispensed was 8 ml per vial, 18 ml per culture tube and jar, and 70 ml per petri dish. Containers were covered with clear plastic lids, sealed with parafilm, and placed under fluorescent lights for six weeks. The number of shoots per explant that formed in petri dishes was three to four times greater than those formed on explants in vials, tubes and jars. However, the number of nodes per shoot were fewer in dishes than in the other containers. Callus formation was excessive in jars to the detriment of shoot production. Vials and tubes had small amounts of callus, while little or no callus was observed in dishes.

805

PB 115

FRACTAL CHARACTERIZATION OF GRAPE BERRY WAX SURFACE STRUCTURE.

Steven C Wiest* and Edward W. Hellman, Kansas State University, Dept Horticulture, Forestry and Recreation Resources, Waters Hall, Manhattan, KS 66506

Scanning electron micrographs of grape berry surfaces, which resemble mountainscapes, contain a wealth of structural information. A typical statistical characterization of features such as root mean square peak-to-peak spacings, peak density, etc., is readily performed on these images. However, a much richer base of information is accessible by analyzing the images with fractal geometry. Fractal box dimension is a quantitative measure of surface roughness, and varies with the contour at which it is determined in both cultivars 'Foch' and 'Perlette', suggesting that the surfaces are multifractal structures. Fourier spectral analyses of the surfaces produce a similar conclusion. Thus, the unambiguous quantitative resolution of cultivars on the basis of their wax surface structure looks promising, but requires further work.

806

PB 118

CHARACTERIZATION OF BERRY CUTICLE AND EPICUTICULAR WAX OF GRAPE CULTIVARS

Edward W. Hellman* and Laurel Raines, Department of Horticulture, Forestry and Recreation Resources, Kansas State University, Manhattan, KS 66506

The cuticle and epicuticular wax layer of grape berries provides a first line of defense against fungal pathogens. A relatively thick cuticle and wax layer may result in enhanced resistance to *Botrytis cinerea* Pers. The structure of epicuticular wax also has been postulated to play a role in *Botrytis* resistance.

To examine the role of cuticle and wax in disease resistance, berries of diverse grape cultivars were sampled to quantify the cuticle and wax layers. Wax surface structure was examined by scanning electron microscopy. Significant differences among cultivars were found for both cuticle and wax measurements. Environmental conditions may influence development of these layers, some cultivars had significantly greater cuticle and wax layers in berries that developed in full sunlight. Visual differences in surface wax appearance were apparent among cultivars. Size, density and orientation of wax platelets varied among cultivars.

807

PB 141

LEAF EPICUTICULAR WAX OF IN VITRO GRAPE PLANTLETS TREATED WITH AND WITHOUT POLYETHYLENE GLYCOL

Masooma Ali-Ahmad, Dept. of Botany, University of Baluchistan, Quetta, Pakistan and Harrison Hughes*, Dept. of Horticulture, Colorado State University, Fort Collins, CO 80523

Scanning electron microscopic (SEM) studies and gravimetric analysis of in vitro cultured leaf surfaces showed reduced epicuticular wax (EW) structurally and quantitatively as compared to greenhouse plants. However, leaves of in vitro plantlets subjected to polyethylene glycol-treatment (PEG) showed an increase in quantitative and structural EW which was similar to that of greenhouse plants. Furthermore, leaves initiated during in vitro culture and which persisted, when transferred to the greenhouse, showed an increase in structural wax as well as in amount, 30 days after transplanting in the greenhouse. Similarly, leaves newly-formed in the greenhouse from in vitro cultured plants developed more dense crystalline structure and greater levels of wax than those leaves observed immediately after removal from culture. A correlation between density of structural EW and amount of EW were observed in in vitro cultured, PEG-treated in vitro cultured and greenhouse grown leaves.

EFFECTIVENESS OF AEROSOL SPRAYS FOR CONTROLLING ROT IN TABLE GRAPES.

M. Ahmed Ahmedullah, Department of Horticulture and Landscape Architecture, Washington State University, Pullman, WA 99164-6414.

Fruit of *Vitis vinifera* cvs. Flame Seedless, Thompson Seedless and Black Monukka were fumigated with 4, 6 and 8 Deccodione Smoke Tables (DST) for 30 minutes. Fruit was stored at 32 F and high relative humidity. Decay control index, freshness of stems and bleaching around the capstem were recorded at 4, 8, 12 and 16 weeks of storage. Size of the aerosol particles was determined using an electrical aerosol analyzer. Fruit was analysed for Deccodione residues.

Lower rates of the fungicide gave unsatisfactory decay control. Eight DSTs successfully controlled decay upto a period of 14 weeks. There was no bleaching of pigments commonly associated with sulfur dioxide fumigation. Majority of the aerosol particles were between 0.18 and 0.32 micrometers. Deccodione residues on the fruit were within the acceptable limits established for Deccodione. There was no perceptible difference in taste between treated and control fruit. This method of decay control could provide a viable alternative to sulfur dioxide fumigation.

STORAGE CONDITIONS AFFECTING QUALITY LOSS OF 'FLAME SEEDLESS' GRAPES

Alfonso A. Gardea*, Miguel Martinez, Alfonso Sánchez, Manuel Báez, and Gustavo González. C.I.A.D., A.C. Apdo. Postal 1735, Hermosillo, Sonora. 83000, México. CIAD/DTAOV/RC/94/009.

Weight loss and dehydration are major problems limiting shelf life of early-season seedless grapes grown in the Sonoran Desert. This research was conducted to assess conditions improving cluster performance in cold storage (4C±1, 90% R.H.). Clusters were packed: 1) loose, 2) wrapped in perforated plastic bags, 3) loose and water supplement added, and 4) in plastic bags + water supplement. After 12 days in storage, weight losses accounted for 7.0, 5.6, 8.5, and 4.0% of initial fresh weight for treatments in ascending order. In another experiment, individual clusters were stored in modified atmospheres using a high gas-permeability film with two different gas-exchange areas of 25 and 75 mm². Cluster weight and gas composition significantly interacted with storage period. During the first 30 days, weight loss was not higher than 0.5% on every sampling date. Gas composition was affected by the effective exchange area. After 47 days, CO₂ concentration was 2.22% and 0.8% in the 25 and 75mm² treatments. At any given time, oxygen content followed the opposite trend with final values of 18.9 and 20.0% for the same treatments. Although cluster quality was highly preserved, eventually rots developed.

'Parasol', respectively. 'Peppermint Cooler', 'Grape Cooler' and 'Orchid Cooler' were the only entries with significantly smaller flower size than 'Parasol'. Appearance ratings at 109 and 141 days after sowing were similar for all entries, however at 166 days 'Dawn Carpet' and 'Pink Carpet' had significantly lower ratings than 15 other entries due to frost damage.

FOLIAR VARIATIONS IN FALL COLOR DEVELOPMENT AMONG FIVE PLANT SPECIES.

Suman Singha*, Bernard Bible, and Edward Corbett, Department of Plant Science, University of Connecticut, Storrs, CT 06269-4067

Variations in the pattern of fall color development in the leaves of *Acer rubrum*, *Acer saccharum*, *Quercus coccinea*, *Oxydendrum arboreum* and *Euonymus alatus* were determined. CIELAB coordinates were measured with a Minolta CR-2000b colorimeter at a marked location on 5 tagged leaves from 2 plants of each species. The changes in hue follow similar trends in these species, but the time of onset varies. Onset of red color development increased variability in hue between leaves of the same species. Based on color changes in *E. alatus* anthocyanin development occurs prior to significant loss of chlorophyll and red coloration remains masked, whereas in *A. rubrum* anthocyanin development occurs in association with or following the loss of chlorophyll. This results in differences in the pattern of hue and chroma development between these species.

FORMULATION OF WILDFLOWER MIXES FOR SITE SPECIFICITY

W. L. Corley*, Dept. of Horticulture, Georgia Experiment Station, Griffin, GA 30223

Contrary to popular notion, many wildflower taxa are quite specific in their edaphic requirements. From a compilation of 35 species adapted to Georgia and the Southeastern U.S., several mixes have been formulated to meet the siting preference of these taxa whose persistence may be annual, biennial, or perennial. Mixes presented are suited for landscape color, partial shade, xeric, mesic, aggressive, and specialty uses.

A COMPARISON OF SEED RATE, SPACING, AND WEED CONTROL METHODS IN THE VIRGINIA TECH TRANSPLANTED MEADOW

Richard L. Harkess* and Robert E. Lyons, Horticulture Department, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0327

Combinations of seed rate, spacing and weed control treatments were evaluated for their effect on the performance of The Virginia Tech Transplanted Meadow technique. The treatments consisted of seed rates of 112 g or 56 g per 90 m²; within-row transplant spacing of 30, 45, or 60 cm; and mulch, oryzalin, or nothing applied for weed control. Plant competition alone was insufficient for effective weed control whereas oryzalin was the best but also reduced the plant stand and floral display. Mulch provided effective weed control with maximum floral display. Close transplant spacing within rows resulted in quick site coverage but this advantage disappeared after 8 weeks when no difference in floral display was observed. Seeding rate did not affect site coverage until the meadow reached maturity at 12 weeks. The lower seed rate allowed more lodging, resulting in a more open appearance and greater light transmission through the canopy. Chemical name used: 4-(dipropylamino)-3,5-dinitrobenzenesulfonamide (oryzalin).

135 POSTER SESSION 20 (Abstr. 810-832)

Landscape/Ornamentals/Turf: Culture and Management

EVALUATION OF CATHARANTHUS (VINCA) CULTIVARS FOR THE LANDSCAPE

T.K. Howe and W.E. Waters, Univ. of FL, Gulf Coast Research & Education Center, 5007 60th St. E., Bradenton, FL 34203

Nineteen *vinca* (*Catharanthus roseus*) cultivars were evaluated for days to flower, flower diameter, flower color, plant dimensions, and appearance during the summer and fall of 1993. Summer: Days from sowing to flower ranged from 58 days for 'Pretty in Pink' to 64 days for 'Pretty in Rose'. Flower diameter ranged from 4.3 to 5.8 cm for 'Orchid Cooler' and 'Parasol', respectively. 'Parasol' produced the largest flower. The 'Carpet' entries (creeping types) were shorter than all others. Appearance ratings were similar among all entries at 85 and 109 days after sowing. Fall: Days from sowing to flower ranged from 51 days for 'Grape Cooler' to 58 days for 'Tropicana Rose'. Flower diameter ranged from 4.3 to 5.1 cm for 'Orchid Cooler' and

ADAPTABILITY OF ELITE SYCAMORE AND SWEETGUM PROVENANCES TO FIELD NURSERY PRODUCTION AND ESTABLISHMENT FOLLOWING BARE-ROOT TRANSPLANTING
Michael A. Arnold* and W. Edgar Davis, Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133, and Tennessee Tech. Univ., School of Agric., Box 5034, Cookeville, TN 38505, respectively

Growth and post-transplant establishment of half-sib seedlings from two elite sycamore (*Platanus occidentalis* L.) mother trees (Westvaco Corp.) and seedlings from a bulk seed lot from elite sweetgum (*Liquidambar styraciflua* L.) trees (Scott Paper Co.) were compared to that of seedlings from a native (Cookeville, TN) sycamore tree and a commercial source of sweetgum seeds. Seedlings were grown under standard field nursery conditions for two years, dug bare-root in autumn, and transplanted to another site to simulate landscape planting. Growth of elite seedlings during production was increased by 11 to 22% in height and 10 to 118 in caliper compared to that of conventional seed sources. Growth differences were maintained following transplanting. The primary lateral root number at transplanting was increased by 2 to 3 on elite sycamore seedlings compared to conventional seedlings. The number of pruning cuts required to eliminate multiple leaders tended to be less for elite seed sources. Survival did not differ among seed sources within a species.

THE EFFECT OF PRUNING ON BRANCH GROWTH IN TWO OAK SPECIES.

A. James Downer*, Matthew Shaw and Dennis Pittenser. University of California Cooperative Extension, 702 County Square Drive, Ventura CA, 93003.

Coast Live Oak (*Quercus agrifolia*) and White oak (*Q. lobata*) are landscape trees which are prone to sudden branch drop. The purpose of this work was to determine the effect of various pruning techniques on growth reduction of one member of a pair of codominant stems. Forty trees of each species were selected with codominant stems. One stem of each pair was pruned by: 1. removing all apical meristems; 2. thinning 50% of branches; 3. heading back to a 10cm stub or, 4. unpruned. Calipers of thinned or headed branches were most retarded while tipped and unpruned branches grew most. Results suggest that pruning by thinning may be an alternative to removal of codominant branches when training young trees.

THE RELATIONSHIP BETWEEN CONTAINER SIZE AND TRUNK DIAMETER OF RIVER BIRCH

Daniel C. Milbocker *, Hampton Roads Agricultural Experiment Station, Virginia Polytechnic Institute and State University, Virginia Beach, VA 23455

Trees grown entirely in containers have slim trunks. Since large tree sizes are measured in terms of their trunk diameter, heavier trunks increase salable tree sizes. River Birch, *Betula nigra* liners were grown in containers that were increased in size at different rates determined by their trunk diameter. These measurements revealed the minimum container size necessary for unobstructed growth and measured the reduction in trunk diameter induced by smaller container sizes.

EFFECTS OF SOIL AMENDMENT AND MULCHING WITH FRESH AND AGED OAK SAWDUST ON FORSYTHIA GROWTH AND SOIL CHARACTERISTICS

Christopher J. Starbuck, Department of Horticulture, University of Missouri, Columbia, MO 65211

A 7.5 cm layer (1 m²) of fresh or 8-year-old oak sawdust was applied to 1.7 m² plots as a mulch or tilled in to a depth of 10 cm. Sawdust-treated and control plots received 0.45 or 227 g of nitrogen applied as ammonium nitrate. Five one-year-old 'Lynwood Gold' forsythia plants were planted in each of the 90 plots in the experiment in September 1992 and were pruned in March 1993 to 20 cm above the soil surface. Plant height, soil pH and levels of Na, organic matter, P, K, Ca, Mg, NO₃ and NH₄ in the soil were determined following the 1993 growing season. Fresh and aged sawdust reduced plant growth by 40 and 31% respectively when incorporated without supplemental nitrogen. Adding the high rate of

nitrogen overcame the inhibition caused by aged but not fresh sawdust. Both materials significantly reduced soil nitrate content even when used as a mulch and reduced phosphorus when incorporated. Organic matter content of sawdust-amended plots averaged over twice that of control plots. Neither material had a significant influence on pH as determined one year after incorporation.

USE OF BIOSOLIDS FOR SOD PRODUCTION

Mouna Benmbarek*, Y. Desiardins and R.R. Simard (1). Université Laval, Pav. Environnement, Ste-Foy (Qc), G1K7P4. (1) Agriculture Canada, Station de recherches, 2560, boul. Hochelaga, Ste-Foy (Qc), G1V2J3, Canada.

Landfilling and incineration constitute the most commonly used methods of biosolid disposal. To minimize the environmental risk, their chemical and biological characteristics have been the subject of several investigations. The present research was undertaken to evaluate the agronomic value of municipal solid wastes (MSW) and composted de-inked sludge (CDS) in a field experiment for sod production. Four variables in a split factorial design, were investigated at two sod farms: compost (MSW and CDS), soil (sandy loam and clay loam), application method (surface applied 6cm and incorporated 20cm), and the application rate (50-100 and 150t/ha). Controls consisted of unfertilized and unamended but fertilized plots. Both experimental sites were seeded with *kentucky bluegrass*. Preliminary data indicate that the two biosolids promoted the sod growth at the rates applied. However, a better plot cover was observed if composts were rototilled at a depth of 6cm as compared to the conventional treated plots. Measurements of root and foliar weights revealed that the turf growth was enhanced with increasing rates, which is probably caused by additional soil macronutrients showed by the analysis. Seed germination and seedling emergence were not delayed as indicated by the observed increase in the water retention capacity of the soil especially at higher compost rates.

PERFORMANCE OF EVERGREEN AZALEAS AS AFFECTED BY SOIL AMENDMENTS AND LANDSCAPE EXPOSURE
John C. Pair, KSU Horticulture Research Center, 1901 East 95th South, Wichita, KS 67233

Since 1974, numerous species and cultivars of evergreen azaleas have been evaluated for hardiness and adaptability to south central Kansas (zone 6). Selections included Kurumes, Gable hybrids, Shammarello hybrids and others in various amended beds and in several landscape exposures. Hardiest cultivars include 'Boudoir', 'Caroline Gable', 'Herbert', 'Karens', 'Pride's Pink', 'Purple Splendor', and 'Snowball' which flowered following -18F (-28C). Moderately hardy were 'Elsie Lee', 'Holland', 'Girard Roberta' and 'James Gable'. Best hardiness was found in cultivars and hybrids with *Rhododendron kaempferi*, and *R. yedoense* var. *poukhanense* parentage. Plants in soil amended with sphagnum peat moss or peat plus sulfur were superior to those in soil containing cotton burrs. Winter shade proved valuable in providing the best landscape site and northeast was generally better than a northwest exposure.

USE OF PELLETIZED NEWSPAPER AS A PEAT MOSS SUBSTITUTE IN GROWING MEDIA

David J. Williams and Michelle Antoinetti, University of Illinois, Department of Horticulture, Urbana, Illinois 61801

Newspaper was pelletized and tested as a peat moss substitute in growing media used for producing bedding plants and woody ornamentals in containers. Varying amounts of urea was added to the newspaper prior to pelletization to improve the C:N ratio of the pellets. Newsprint had a C:N ratio of 800:1. One quart of a 28% nitrogen solution per ton of paper consistently changed the C:N ratio to 400:1. Additional quantities of the 28% N solution did not lower the C:N ratio due to volatilization. The addition granular urea at 5.0 lbs. and 10.0 lbs. of urea per 300 lbs of newsprint altered the C:N ratio to 50:1 and 18:1 respectively. Media containing pelletized paper expanded about 40% in volume when water was added. Following the first leaching electrical conductivity of the leachate was slightly elevated when compared to the check. In nine subsequent leachings the electrical conductivity was not significantly different than the check. The pH of the leachate averaged 7.2.

EVALUATING PULP AND PAPER SLUDGE AS A SUBSTITUTE FOR PEAT MOSS IN CONTAINER MEDIA

R.R. Tripepi*, M.W. George¹, and A.G. Campbell², Plant Sci. Div.¹ and Forest Prod. Dept.², Univ. of Idaho, Moscow, ID 83844-2339

Pulp and paper sludge is a byproduct of paper production, yet this fibrous material may be suitable as an alternative amendment for peat moss in container media. Newsprint mill sludge was composted 6 weeks and cured before use. One-year-old seedlings of lilac (*Syringa vulgaris* L.) and amur maple (*Acer ginnala* Maxim.) as well as rooted cuttings of cistena plum *Prunus x cistena* Hansen) were planted in 3-liter pots that contained a barksand (2:1 by vol) mix, 25% or 50% peat-amended media, or 25% or 50% sludge-amended media. After 14 weeks outdoors, shoot dry weight and changes in plant height were measured. All species planted in sludge-amended media grew as well as those potted in peat-amended media or the bark:sand mix. In fact, some species grew best in sludge-amended media. Lilac seedlings planted in 25% sludge produced almost double the amount of shoot dry weight and were 80% taller than plants in the bark:sand mix or 25% peat. Maple plants grown in 500% sludge produced over 100% or 3590 more shoot dry weight than those grown in 25% or 50% peat-amended media, respectively. Plum cuttings potted in 25910 sludge grew at least 53% taller than plants grown in either peat-amended medium. These results indicate that composted newsprint sludge can be used as a peat moss substitute in a container medium for the landscape plants tested.

822

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PINE BARK SOIL AMENDMENTS AND NUTRITION AFFECT GROWTH AND DROUGHT TOLERANCE OF *VIBURNUM PLICATUM* VAR. *TOMENTOSUM* 'MARIESII'

Carleton B Wood*, Timothy J. Smalley¹, Mark Rieger¹

Department of Horticulture¹, University of Georgia, Athens, GA 30602.

Container-grown *Viburnum plicatum* var. *tomentosum* 'Mariesii' were planted in tilled beds and tilled beds amended with aged pine bark. After transplanting, plants were fertilized at three different rates: no fertilizer, 18.4 g of N m⁻², and 36.8 g of N m⁻². A 31 day drought was begun 73 days after planting. Fertilization of tilled plots induced ammonium toxicity, which caused a linear reduction in leaf area, shoot dry weight, and root dry weight. Fertilization of amended plots had no effect on shoot growth but reduced root growth by 54%; thus, amendments ameliorated ammonium toxicity. Between 10 and 28 days after beginning the drought, plants in unfertilized-amended plots maintained higher relative leaf water contents (RLWC) and relative leaf expansion rates (RLER) than plants in unfertilized-tilled plots. Amendment induced nitrogen deficiencies contributed to the increased drought tolerance of plants from unfertilized-amended plots. Since fertilized plants developed symptoms of ammonium toxicity, we were unable to determine if increasing fertility would counteract the drought tolerance conferred by pine bark soil amendments.

823

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CAN A POROUS CERAMIC SOIL AMENDMENT LIMIT WATER STRESS OF CONTAINER-GROWN *IMPATIENS* 'ACCENT RED'?

Michael B. Triff*, Timothy J. Smalley¹, Mark Rieger¹, David Radcliffe², Dept. of Horticulture¹ or Crop and Soil Sciences², Univ. of Georgia, Athens, GA 30602.

Isolite is a ceramic-like, porous soil amendment purported to sustain plant growth under reduced irrigation and increase plant survival during drought. The purpose of this greenhouse experiment was to determine the effect of an Isolite-amended soilless container medium on: (1) growth under reduced irrigation frequency and (2) water stress during drought of *Impatiens x hybrids* 'Accent Red'. On 2 June 1993, seedlings were transplanted into 13.2 liter black plastic pots containing a 4:1 composted pine bark:coarse sand (vol.) medium amended with Isolite CG-1 granules at rates of 0%, 10%, 15%, and 20% (vol.). Study I. Seedlings were irrigated with 500 ml tap water every two days for two weeks followed by a 4 week schedule of 500 ml tap water every 1, 2, 3, 4, or 5 days. In general, growth parameters were explained by irrigation treatment effects and did not differ with Isolite rate. Growth indices ranged from +54% to +143%, while final visual quality grades ranged from 2.4 to 5.0 (5-point scale), shoot dry weight from 8.7 to 30.7 g, root dry weight from 2.0 to 7.9 g, and leaf area from 0.14 to 0.48 m². Study II. Seedlings were irrigated with 500 ml tap water every 2 days for five weeks followed by a two week drought. Plant water status parameters were similar at all rates of Isolite. Leaf expansion rates ranged from +89% to +98%, while a final mid-day xylem pressure potential of -0.4 MPa and a final visual quality grade of 2.0 were uniform across all treatments. Under these conditions, Isolite did not limit water stress of container-grown *Impatiens* 'Accent Red'.

824

PB 275

UTILIZATION OF MSW COMPOST IN CONTAINER MEDIA.

Richard C. Beeson, Jr. * CFREC-Sanford, 2700 E. Celery Ave., Sanford, FL 32771

Municipal Solid Waste (MSW) compost was evaluated as a component of landscape ornamental container media to reduce irrigation requirements and identify beneficial uses of the material. MSW compost was blended at 10 to 40% by volume with pine bark and coarse sand. Three landscape ornamentals

were produced to marketable 10 liter-size plants in each medium during an 18-month production period. Twenty percent MSW compost produced similar shoot and root growth to the "standard" medium consisting of 20% Florida sledge peat. Thirty or 40% MSW compost inhibited root growth to the lower depths of a container during the rainy summer months. This inhibition was no longer evident after growth during the dry late fall to early spring months. Root growth inhibition was due to decreased aeration rather than phytotoxic leachate. Up to 20% MSW compost can be used for container media in wet climates whereas 40% would produce high quality plants under dry climates.

8 2 5

PB 278

THE RESPONSE OF BEDDING PLANTS TO THE INCORPORATION OF HYDROGEL INTO LANDSCAPE BEDS

Jennifer L. Boatright* and J. M. Zajicek

Department of Horticultural Sciences, Texas A&M University, College Station, Texas 77843-2133

Hydrogel (HydrosourcTM, Western Polyacrylamide, Inc.) was incorporated into 102 cm x 122 cm landscape beds at 25, 50, 75, or 100 lbs per 1000 sq ft. Weed barrier and 2 cm of pine bark mulch were added to the top of each bed. Controls consisted of 1) no hydrogel with weed barrier and mulch and 2) no hydrogel with mulch but no weed barrier. Each treatment was replicated four times with ten plants of petunia, marigold, and vinca planted per bed, for a total of forty plants of each species per treatment. Flower number of vinca and petunia increased with hydrogel incorporation, 75 lbs of hydrogel having the greatest number of flowers. Petunia also had higher visual ratings with increased hydrogel rates. Soil temperatures directly under the mulch and 10 cm below the mulch, at 1400 HR, were 49C and 40C respectively for controls, compared to 42C and 36C for beds with hydrogel.

8 2 6

PB 301

WATER USE OF LANDSCAPE SHRUBS SURROUNDED BY 4 DIFFERENT MULCHES

Shelley A. McReynolds*, J.M. Zajicek, W.A. Mackay and J. L. Heilman
Departments of Horticultural Sciences and Soil and Crop Sciences, Texas A&M University, College Station, Texas 77843-2133

A study was conducted to explore how different mulches affect water use of landscape plants. Plots 4.9 m x 7.3 m, were covered with 5cm pine bark, cypress, white rock, or clay aggregate. 3 potted plants of *Ligustrum japonicum* (wax-leaf ligustrum) and *Photinia x fraseri* (red tip photinia) were placed in each plot so that the top of each pot was at ground level. 1 plant of each species was planted directly into each plot. Water loss was measured on a daily basis, both gravimetrically and using heat balance stem flow gauges, during both the 1992 and 1993 growing seasons. Stomatal conductance was measured periodically during each growing season. Surface, air, and soil temperatures at two depths were recorded. During 1992, pine bark mulched plants consistently used more water than the other treatments, as opposed to summer 1993 when the most water was used by plants over white rock. Surface temperatures of pine bark, cypress and clay aggregates were higher than those of white rock both years, by as much as 20C, while temperatures under the mulch varied as much as 5C between pine bark and white rock.

8 2 7

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ESTIMATING TURFGRASS EVAPOTRANSPIRATION USING ATMOMETERS AND EMPIRICAL MODELS.

Jack D. Fry, Steven C. Wiest* and Ward S. Upham, Kansas State University, Dept. Horticulture, Forestry and Recreation Resources, Waters Hall, Manhattan, KS 66506

Evapotranspiration from tall fescue, perennial ryegrass and zoysiagrass turfs during the summers of 1992-3 was compared to evapotranspiration estimates from an evaporation pan, a black Bellani plate, and several empirical combination models. Actual measurement of turf water use was made with small weighing lysimeters. Soil was maintained at field capacity. Data were collected on 51 dates between June and September. Tall fescue was clipped weekly at 7.6 cm whereas ryegrass and zoysiagrass were clipped 3 times weekly at 2.5 cm. Although differences between the grass species existed, in general the rankings of estimate precision were Bellani plate > evaporation pan > empirical models when compared with measured evapotranspiration rates.

IMPROVED WATER USE EFFICIENCY WITH MODIFIED CONTAINERS
D.C. Fare*, C.H. Gilliam. and G.J. Keever, Auburn University, AL 36849

Improved water use efficiency exists for plants grown in modified containers to minimize leaching and reduce irrigation frequency which subsequently reduces NO₃-N leachate. *Salvia splendens* 'Bonfire' and *Impatiens wallerana* 'Pink' (super elfin hybrid) were potted in ProMix BX medium (Premier Brands, Inc., Stamford, CT) into nine container styles with modified drainage holes to determine leachate volume and quantify NO₃-N leached. Three styles had four drainage holes on the container side with hole diameters of 0.5, 1.0, and 1.9 cm, respectively; three styles had four drainage holes on the container side and one drainage hole in the bottom center with hole diameters of 0.5, 1.0, and 1.9 cm, respectively; and three styles had one drainage hole in the bottom center with hole diameters of 0.5, 1.6, and 1.9 cm, respectively. Plants were hand watered when an individual container's medium reached 80% of container capacity. Leachate volume, irrigation frequency, and leachate NO₃-N was reduced as drainage size hole decreased in size and number. Plant quality was similar among container modifications.

WETTING AGENT EFFECTS ON TURF SOIL-WATER REPELLENCY

John L. Cisar* and Karen E. Williams, University of Florida, 3205 South West College Avenue, Ft. Lauderdale, FL 33314

Soil-water repellency is often a problem for turfgrass grown on sand soils. Wetting agents used to alleviate repellency often provide mixed results. We evaluated AquagroL and an experimental material (ACA 864) at 0, 7, 14, and 21ml/m² applied monthly to tifgreen bermuda grown on a soil-water repellent Margate fine sand over 6 months. Alleviation of repellency was based upon water drop penetration time (WDPT). Wetting agents did not effect turf quality, cover, or discoloration. Wetting agents did not reduce repellency 1 month after initial application. At 2 months, ACA 864 at 21ml/m² significantly reduced WDPT. With repeat applications, lower rates of ACA 864 provided reductions in WDPT similar to the highest rate of ACA 864, suggesting an additive effect over time. There was a decline in WDPT for all wetting agent treatments, except the control, over time. Repellency decreased with soil depth, and repeat wetting agent application reduced WDPT at lesser depth.

FORCING HERBACEOUS PERENNIALS TO FLOWER AFTER STORAGE OUTDOORS BENEATH A THERMOBLANKET

Jeffery K. Iles* and Nancy H. Agnew, Department of Horticulture, Iowa State University, Ames, IA 50011-1100

Nine herbaceous perennial species were evaluated for use as flowering pot plants for late winter and early spring sales. Plugs of *Achillea* 'King Edward', *Arabis sturii*, *Armeria* 'Alba', *Bergenia* 'New Hybrid', *Chrysogonum virginianum*, *Dianthus* 'War Bonnet', *Phlox* 'Chattahoochee', *Platycodon* 'Sentimental Blue', and *Veronica* 'Sunny Border Blue' were established in 14-cm (0.8-liter) round plastic containers, grown for one season, and covered with a thermoblanket for winter. Five plants of each species were transferred to a 21 ± 3C glasshouse for forcing under natural daylength at six 10-day intervals beginning 1 Dec. 1993. By this date plants had experienced approximately four weeks of temperatures below 5C. *Ambis*, *Chrysogonum*, and *Phlox*, species that naturally flower in spring, were the most floriferous. Days to first flower for *Arabis* decreased from 30 to 26 while flower number increased 44% by the 20 Dec. forcing date. For *Phlox*, days to first flower decreased from 36 to 31 by 20 Dec., but flower numbers were similar regardless of forcing date. *Chrysogonum* averaged eight flowers throughout the study, but days to first flower increased from 25 (1 Dec.) to 31 in all following forcing dates.

DISTURBED AND UNDISTURBED COMMUNITY COMPARISON USING GIS, VEGETATION, AND WATER QUALITY ANALYSIS

I.H. Perry*, J.M. Zajicek and S.L. Hatch
Departments of Horticultural Sciences and Rangeland Ecology & Management, Texas A&M University, College Station, TX 77843-2133

Understanding the effect of catastrophic disturbances on natural communities is necessary and vital to planning and executing development and to reclamation and restoration projects. Two nearby sites one catastrophically disturbed by flooding and one undisturbed area were compared. Field vegetation analysis three years after the flood in the disturbed area showed changes in the community structure along the

stream, no overstory and a majority of obligate emergent wetland vegetation. In the undisturbed site, community structure along the stream is uniform; the overstory is well-developed, and herbaceous plants are predominantly facultative wetland but with few emergents. The field water quality analysis of temperature, pH, dissolved oxygen and specific conductivity are compared in the areas. GIS (Geographic Information System) analysis used the USGS 1:24,000 maps of the area and SCS county soil survey maps to analyze erosion risk, soil types, topography and vegetation potential in the 200 km² Miller Springs Natural Area and the immediately surrounding 5 10 km² watershed.

141 POSTER SESSION 21 (Abstr. 833-841) Seeds and Seedlings

EFFECTS OF DIFFERENT DRYING METHODS AND MOISTURE LEVELS ON SOYBEAN SEED VIABILITY AND VIGOR

Jian Fang* and E.E. Roos, USDA-ARS National Seed Storage Laboratory, 1111 South Mason St., Fort Collins, CO 80521-4500.

Achieving the optimum moisture content for long-term seed storage usually requires that seeds be dried after receipt at a genebank. Soybean (*Glycine max* L.) seeds were dried using four procedures: over concentrated H₂O₂, over silica gel, at 15% relative humidity (RH), or in an oven at temperatures of 30, 35 and 40C. Following drying seeds were stored at 40C for 10 days and at 5C for one yr. Seeds were evaluated for germination and vigor (root length, dehydrogenase, and leachate conductivity). Initial moisture content (mc) was reduced from 8.3% to between 6.6% (24 hr at 30C) and 4.6% (H₂O₂, 30 days). Germination and vigor of seeds was essentially unchanged immediately following the drying treatments. Storage for 10 days at 40C reduced germination by up to 12% while storage for one yr at 5C had a similar effect (14% maximum loss) for most treatments. The treatments having the lowest drop in germination after one yr of storage treatment were the silica gel and the 30C oven treatments, which dropped only 3% in germination. Drying at 15% RH, also resulted in a lower loss in germination. In all three tests, vigor of seeds after storage at 40C was higher than controls for the silica gel and 15% RH treatments as well as for the 30C and 35C oven treatments. Storage at 5C gave similar results for all three vigor assessments.

DEVELOPMENT OF SEED QUALITY IN RED CABBAGE

David W. Still and Kent J. Bradford*, Department of Vegetable Crops, University of California, Davis, CA 95616-8631

Brassica crops have an extended flowering period due to both progressive development within a given raceme and variability among multiple racemes. Early harvest can result in poor seed quality due to immaturity, while delayed harvest may sacrifice yield due to shattering. To characterize the development of seed quality, we measured maturity indices and conducted vigor tests on hybrid red cabbage (*Brassica oleracea* var capitata) seed harvested weekly starting 33 days after full bloom (DAF). Viability and germination rate increased from the top to the bottom of the raceme, and were maximal by 40 and 48 DAF, respectively. After 48 DAF, there was little difference in seed quality due to position on the raceme. Seed dry weight also reached a plateau by 48 DAF, when rapid dehydration began. Sensitivity of germination to inhibition by reduced water potential or abscisic acid (ABA) was assessed using a threshold model based upon germination rates. Germination became less sensitive to both factors and more uniform during maturation, with -1.0 MPa or 50 µM ABA being required to inhibit germination by 50% after about 48 DAF. Seed ABA content reached a peak of 10 µg/g dry wt. by 40 DAF, then declined linearly to 1.5 µg/g dry wt. by 68 DAF. Overall, optimal seed quality was attained at 54 DAF.

HIGH-TEMPERATURE EFFECTS ON SOLUBLE OLIGOSACCHARIDE LEVELS IN SPINACH SEEDS DURING IMBIBITION AND GERMINATION

Virgil Esencse* and Daniel I. Leskovar, Texas Agricultural Experiment Station, Texas A&M University, Uvalde, TX 78801

Spinach (*Spinacia oleracea*, L. cv. 'Ark88-354'. 'Fall Green', 'Cascade') seeds of varying sensitivities to high temperatures during imbibition and germination were subjected to constant 18, 30 and 36°C

for 96 hours during imbibition. Those cultivars less sensitive to high temperatures ('Ark88-354' and 'Fall Green') imbibed water more rapidly at higher temperatures and had greater initial levels of raffinose and sucrose than the sensitive cultivar 'Cascade'. Glucose levels were initially zero in all cultivars and increased slightly with time. Germination was more rapid at 18°C and 30°C in 'Ark88-354' and 'Fall Green' than with 'Cascade'; the latter also failed 10 germinate at the higher temperature. Raffinose and sucrose have been implicated in membrane stabilization during desiccation and extreme low temperatures. They may serve a similar role during imbibition and germination of spinach at high temperatures, reducing secondary thermodynamicity.

836

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EFFECTS OF PRIMING ON MUSKMELON SEED STORABILITY
Melkizedek O. Oluoch* and Gregory E. Welbaum, Department of Horticulture, Virginia Tech, Blacksburg, VA 24061-0327.

Priming (controlled hydration followed by drying) has been shown to decrease seed storage life in some species. The germinability of primed (0.3 M KNO₃, 6 d, 25°C) and unprimed muskmelon (*Cucumis melo* L., cv. PMR 45) seeds were compared after storage for 9 yrs at less than 20°C and 6% moisture content (MC) (dwt basis). Germination performance was compared at 30°C in water and polyethylene glycol solutions of -0.2, -0.4, -0.6, -0.8, and -1.0 MPa water potential or in water at 15, 20, and 25°C. Seeds were also germinated in field soils at 17, 19, and 21% (dwt. basis) MC in a greenhouse. Some seeds were subjected to controlled deterioration at 20% MC and 45°C for 72 hrs prior to testing. The germination percentage and rate of stored, primed seeds at 30°C and all water potentials was less than stored, unprimed seeds. At 30°C, stored, unprimed seeds germinated more rapidly and to higher percentages at -0.2 MPa than in water, while germination percentages and rates of stored, primed seeds were essentially the same. At 15, 24, and 25°C, stored, primed seeds outperformed unprimed seeds in all germination tests. In saturated soils at 21% MC, there was no germination of either stored, primed or unprimed seed. At 17% soil MC, stored, primed seeds germinated 73% compared to only 56% for unprimed seeds. The enhancement due to priming was retained after 9 yrs of storage at germination temperatures <30°C. At higher temperatures, the germination of unprimed seeds was superior to primed.

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A COMPARISON OF BROCCOLI SEED PRIMING TREATMENTS

Lewis W. Jett* and Gregory E. Welbaum, Department of Horticulture, Virginia Polytechnic Institute & State University, Blacksburg, VA 24061.

Various osmotic solutions and solid carriers have been used to prime (controlled hydration followed by drying) seeds. Broccoli (*Brassica oleracea* L., var. *italica*, cvs. Brigadier and Earldawn) seeds were primed in solutions of polyethylene glycol, potassium nitrate (KNO₃), and mannitol or calcium silicate (Micro-cel E) and vermiculite to determine which treatment provided the greatest enhancement of germination. Germination percentage and rate as well as head yield were determined in a series of laboratory, glasshouse, and field experiments over a three year period. Water potentials (Y) ranged from -0.8 to -2.6 MPa at 20°C for both osmotic solutions and carriers. The duration of the priming treatments were 3, 7, or 10 days. All priming treatments, except KNO₃ and mannitol, consistently reduced the mean time to germination in the laboratory, reduced the mean time to field emergence, increased final stands, but did not affect the mean time to harvest. However, solid phase was more effective than osmotic priming at each Ψ tested. The best solid priming mixture was 1.0:0.8:1.8 (seed:carrier:water) for 7 days at 20°C using Micro-cel E. This treatment was measured to have a Y = -1.2 MPa, and other types of priming at the same Y were less effective. The Y threshold below which no priming effect was obtained was Ψ = -2.4 MPa. Priming response was closely associated with, but not entirely dependent on, the Ψ of the treatment.

838

PB 358

CONTROL OF LOW-TEMPERATURE GERMINATION OF MELON (CUCUMIS MELO L.) SEEDS BY SEED-COAT STRUCTURE AND OXYGEN AVAILABILITY.

M. Edelstein*, F. Corbineau², J. Kigel³, H. Nerson¹
1 Dept. Vegetable Crops, ARO, Newe Ya'ar, P.O. Haifa 31-999, Israel; 2 Université Pierre et Marie Curie, 15252 Paris Cedex 05, France; 3 Dept. Agricultural Botany, Hebrew University of Jerusalem, Fac. Agriculture, Rehovot, Israel

The involvement of the seed coat in low temperature germination of melon seeds was examined in two accessions differing in their ability to germinate at 14°C: 'Noy Yizre'el' (NY) (a cold-sensitive cultivar) and 'Persia 202' (P-202) (a cold-tolerant breeding line). Submerging the whole seed, or covering the hilum with lanolin, strongly depressed germination of NY, but not of P-202. Accessions differed in germination response to decreasing O₂ concentration, with NY showing higher sensitivity to hypoxia. Intercellular spaces in the outer layer of the

seed-coat were evident in the more tolerant P-202, while in the sensitive NY this layer is completely sealed. Sensitivity to hypoxia was greater at 15°C than at 25°C and was greater in NY than in P-202. It is proposed that the seed-coat imposed dormancy at low temperature in NY is the combined result of more restricted oxygen diffusion through the seed coat and a greater embryo sensitivity to hypoxia, rather than imbibition impairment or a physical constraint.

839

PB 381

EFFECTS OF ANTITRANSPIRANT AND POLYACRYLAMIDE GEL ON EARLY GROWTH OF MUSKMELON (CUCUMIS MELO L. CV. HILINE).
Entin Daningsih, Laurie Hodges*, and James R. Brandle, Department of Horticulture and Forestry, University of Nebraska, Lincoln NE 68583-0724

Field experiments were conducted in 1991, 1992, and 1993 to evaluate the effects of antitranspirant (Folicote, Aquatrol Inc.) and polyacrylamide gel (Supersorb, Aquatrol Inc.) on early growth of muskmelon. A RCBD with split plot arrangement was used with sheltered and exposed areas as the main treatments and seven combinations of antitranspirant spray and gel dip applications as sub-treatments. Two greenhouse experiments were also conducted to simulate field research. A RCBD with seven treatments described as sub-treatments in the field research was used in the greenhouse studies. Based on destructive harvests in the field, treatments and sub-treatments did not affect dry weight or leaf area index. Specific contrasts, however, showed that gel application significantly increased dry weight and leaf area index whereas the spray application tended to reduce these factors during the first three weeks after transplanting. Significant differences between dip and spray sub-treatments disappeared by five weeks after transplanting. In both greenhouse experiments, gel dip application increased dry weight and leaf area index of muskmelon at all observations from 2 weeks to five weeks after transplanting. We conclude that gel application generally will provide more benefit during early muskmelon growth compared to the use of antitranspirant spray.

840

PB 384

EFFECT OF SIX PRIMING TREATMENTS AND TWO TEMPERATURES ON THE EMERGENCE OF SIX VARIETIES OF CAPSICUM ANNUUM

Anne K. Carter* and Dennis Clason, Dept. of Agronomy and Horticulture and Dept. of Experimental Statistics, New Mexico State University, Las Cruces, NM 88101

Six varieties of *Capsicum annuum*, L. were selected for the study (Joe Parker, NuMex Sweet, NuMex R Naky, Tam VeraCruz, Sandia, and Conquistador). All seeds were primed in -.90 MPa NaCl, -1.35 MPa NaCl; -1.24 MPa CaCl₂, -1.94 MPa CaCl₂, -1.43 MPa K₂HPO₄, -2.09 MPa K₂HPO₄, and a nonprimed control at 23°C in an incubator for 5 days. Seeds were dried for 2 days at 23°C, then planted in soilless media under a 10/14 day/night cycle in incubators at either 23°C or 15°C. Emergence was counted daily for 21 days. Statistical analysis was performed on the rate of emergence and the maximum number of seeds emerged by day 21. There was a significant variety x treatment x temperature interaction when the rate of emergence was used as the variable. Priming improved the rate of emergence over the control among all varieties, treatments and temperatures, but the effect of seed priming on the maximum emergence varied from one variety to the other. Priming was more effective at 15°C. The start of emergence averaged 3.5 days over the control at 23°C and 7.3 days over the control at 15°C. Seeds emerged an average of 7 days faster at 23°C than at 15°C. Sandia and Conquistador appear to be sensitive to priming treatments and temperature.

841

PB 387

PHOSPHORUS RATES AND MEDIA FOR PRODUCTION OF TOMATO TRANSPLANTS USING THE FLOAT SYSTEM

Jim E. Wyatt* and Marla C. Akridge, University of Tennessee, West Tennessee Experiment Station, 605 Airways Boulevard, Jackson, TN 38301

Tomato transplants were grown in plastic foam trays floated in nutrient solutions using a system adapted from tobacco transplant growers. Nutrient solutions were compared which contained equivalent amounts of nitrogen and potassium and either 35 or 70 mg·liter⁻¹ phosphorus (P). Growing media tested were 1) Jiffy-Mix*, 2) Pro-Mix*, 3) horticultural vermiculite, or 4) perlite. The higher P rate caused increases in stem diameter, and in plant fresh and dry weight. Plant height, root dry weight and leaf area were not affected by P rate. Transplants grown in Pro-Mix* had significantly greater plant height and stem diameter than other media. Leaf area, and plant fresh and dry weight did not differ between Pro-Mix* and Jiffy-Mix*. Vermiculite and perlite produced smaller tomato transplants and should not be considered when using this production system.

142 POSTER SESSION 22 (Abstr. 842-848)

Floriculture: Postharvest

842

PB 482

INFLUENCE OF STOMATA AND TRANSPIRATION ON *ANTIRRHINUM MAJUS* L. POSTHARVEST LONGEVITY

Susan M. Stieve* and Dennis P. Stimart, Department of Horticulture, University of Wisconsin, 1575 Linden Dr., Madison, WI 53706-1590

Eighteen commercially used white *Antirrhinum majus* (snapdragon) inbreds, a hybrid of Inbred 1 x Inbred 18 (Hybrid 1) and an F₂ population (F₂) of Hybrid 1 were evaluated for stomatal size and density and transpiration rate to determine their affect on postharvest longevity. Stems of each genotype were cut to 40 cm, placed in distilled water and discarded when 50% of florets wilted or browned. Postharvest longevity of inbreds ranged from 3.7 to 12.9 days; Hybrid 1 and the F₂ averaged 3.0 and 9.1 days postharvest, respectively. Leaf impressions showed less than 3% of stomata were found on the adaxial leaf surface. Inbred abaxial stomatal densities ranged from 128.2 to 300.7 stomata mm⁻²; Hybrid 1 and the F₂ averaged 155 and 197 stomata mm⁻², respectively. Transpiration measurements on leaves of stems 24 hr after cutting were made with a LI-COR 1600 Steady State Porometer. Statistical analysis showed inbreds were significantly different based on postharvest longevity, stomatal size and density and transpiration of cut stems.

843

PB 485

EFFECT OF SUCROSE SOLUTIONS ON POSTHARVEST LIFE OF SATIN FLOWER (*Clarkia arnoeana*)

Robert G. Anderson*, Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington KY 40546

Greenhouse grown cut stems of satin flower were used in a series of postharvest experiments to determine the effect of sucrose on flower life, flower quality and the overall vaselife. Experiments in 1993 compared 0, 0.5, 1.0 and 2.0% sucrose in tap water with and without a biocide (4 ppm sodium hypochlorite). Cut stems of 'Grace Rose Pink,' 'Grace Salmon' and 'Grace Red' were harvested, stored in a refrigerator overnight at 1-2° C.; all cut stems were maintained in randomized individual vases in a room kept at 22-23° C with fluorescent lighting (50 ft.c.) from 0800-2000 HR. Postharvest performance was best in tap water, tap water + biocide, and 0.5% sucrose + biocide with excellent flower opening and flower quality for 10-14 days. Leaf yellowing and leaf necrosis increased greatly with the increasing concentrations of sucrose. Flowers of 'Grace Salmon' showed significant petal necrosis in the treatments with higher concentrations of sucrose.

844

PB 488

POST-HARVEST CHARACTERISTICS OF CUT FLOWER SPIKES OF *LUPINUS HAVARDII*

Tim D. Davis*, Wayne A. Mackay, and N. Sankhla, Texas Agricultural Experiment Station, Texas A&M Univ. Research & Extension Ctrs., 17360 Coit Rd., Dallas, TX 75252 & 1380 A&M Circle, El Paso, TX 79927

Lupinus havardii (Big Bend bluebonnet) is native to a narrow geographical range along the Rio Grande River in southwest Texas and produces attractive blue flower spikes which have potential as cut flowers. Without any post-harvest treatments, these spikes had an average vaselife in water of about 7 d. During this period, an average of about 13 florets were abscised per spike. When preconditioned for 4 h in 40-80 mg/liter silver thiosulfate (STS), vaselife increased to 11 days and only 1-3 florets were abscised per spike. Post-harvest treatment of the spikes with 25-50 mg/liter oxime ether, a new ethylene inhibitor, surprisingly enhanced floret abscission and shortened vaselife. The basis for this response is not clear. Storage of STS-preconditioned spikes in water at 5°C for 72 h only decreased vaselife by about one day compared to unstored controls. Dry post-harvest storage at 5°C for 72 h caused severe wilting, but upon rehydration these spikes still had a vase/life of about 8 d. These results indicate that cut flower spikes of *L. havardii* have good post-harvest qualities and can be stored for up to 3 d without seriously limiting vaselife.

554

845

CAUSES OF POSTHARVEST LEAF YELLOWING IN EASTER LILIES

Anil P. Rartwala* and William B. Miller¹. ¹Department of Horticulture, Clemson University, Clemson, SC 29634-0375. and P. Allen Hammer² and Terri Kirk², ²Department of Horticulture, Purdue University, West Lafayette, IN 47907-1165

The possible factors contributing to leaf yellowing during the postharvest phase of Easter lilies (*Lilium longiflorum* Thunb.) were investigated. Higher levels of growth retardants, forcing under negative DIF conditions, cold storage (4.0°C) at the 'puffy bud' stage and shipping stress were shown to increase leaf yellowing during postharvest holding. Concentrations of soluble carbohydrates and starch under inductive and non-inductive conditions were determined to investigate the correlation of it to leaf yellowing. Lilies grown under negative DIF had lower concentrations of leaf, stem and flower soluble carbohydrates and starch compared to plants grown under positive DIF. Investigation of diurnal fluctuations of leaf carbohydrates revealed low carbohydrate levels in negative DIF-forced plants at all times during the diurnal cycle. Supplemental light (50-60 µmol m⁻² s⁻¹) during cold storage increased leaf carbohydrate levels. Higher levels of bud abortion and reduced flower longevity were also observed under conditions inductive of leaf yellowing.

GLYCERIN/DYE SOLUTION UPTAKE IN PRESERVED DECORATIVE FOLIAGE

Alan Stevens* and Karen Gast, Department of Horticulture, Forestry and Recreation Resources, Kansas State University, Manhattan, KS. 66506.

The commercial production of preserved plant materials for decorative purposes is expanding. The industry, once dominated by a relatively small number of large wholesale firms, marketing through traditional retail florists, is undergoing change. A large retail craft supply industry, country accent retail stores and home-based businesses selling at craft fairs have greatly expanded the market for preserved plant materials. Glycerin has often been used to maintain flexibility and reduce breakage of preserved foliage. Dyes are added to the glycerin to add color to the tissue as the chlorophyll fades. Competition in the marketplace places constant pressure on controlling costs. Technical grade dyes of lower dye purity and higher salt concentrations have a lower cost per gram of material than food grade dyes. The effect of the two grades of dye on uptake of glycerin/dye solutions into *Eucalyptus cinerea* were measured. Under both growth chamber and laboratory room environments glycerin solution alone was systemically absorbed at a greater rate and in larger quantity than either grade of dye. A variation in systemic absorption between grades of dye was also indicated.

8 4 7

PB 515

SHORT INTERRUPTIONS OF THE COLD CHAIN REDUCE THE VASE LIFE OF ASTER ERICOIDES, CHRYSANTHEMUM, DIANTHUS, AND GYPSOPHILA CUT FLOWERS

Rik van Gorsel* and Marc Ravesloot, Research Station for Floriculture, Linnaeuslaan 2a, 1431 JV Aalsmeer, Netherlands

Postharvest temperature and transport duration affect the vase life of cut flowers, necessitating temperature control throughout the marketing chain. However, in practise interruptions of this cold chain often occur, e.g. at the auction, airport or other transfer points. We investigated the effect of an early interruption of the cold chain on water loss, rate of development and vase life of four cut flower species. The experiment had a factorial design: three durations of interruption (8.16 and 40 h), each at five temperatures (8, 12, 16, 20 and 24°C), and three containers (replicates) per treatment. A standard marketing chain simulation and vase life evaluation followed each treatment. Controls were 0 h interruption with and without marketing chain simulation. The experiment was carried out twice for each species. Water loss was proportional to vapor pressure deficit, with a sometimes synergistic effect of temperature. A short exposure to 20°C accelerated the development of all flower species compared to continuous 8°C. The effect of the higher temperature became more apparent later in the marketing chain. Averaged over the interruption temperatures, a one-day delay in the marketing chain resulted in a one day (Aster and Gypsophila) to three days (Dianthus and Chrysanthemum) decrease in vase life. A temperature of 20°C for 40 hours reduced the vase life by 30% to 40% compared to continuous 8°C.

CONTROLLED ATMOSPHERIC ENVIRONMENTS AND THEIR EFFECTS ON APHIDS AND WESTERN FLOWER THRIPS ON FLORAL PRODUCTS

Virginia R. Walter*, Mark D. Shelton, and Richard A. Cavaletto, California Polytechnic State University, San Luis Obispo, CA 93407

Shipments of floral products to Pacific rim markets must meet stringent pest-free requirements. Conventional fumigation methods with methyl bromide will soon become unavailable. Studies show that controlled atmosphere (CA) environments can offer effective insect

control. Currently, CA overseas marine shipping is occurring with fresh fruits and vegetables. These shipments use microprocessors to precisely control O₂, CO₂, temperature and relative humidity. This study is evaluating similar commercial shipments with fresh flowers and foliage under low temperature and low O₂ and high CO₂ atmospheres. Preliminary results with shipments conducted by TransFresh to Guam indicate that properly maintained CA shipments of 0.5 % O₂ kill insects and that flowers in properly maintained atmospheres can withstand 14 days of marine shipment with minimum effect on post-harvest life. Adequate regulation of CA storage during transit seems to be the primary limitation to the expansion of floral markets using this method of shipment.

143 POSTER SESSION 23 (Abstr. 849-859A) Ornament&/Floriculture: Weed & Root Growth Culture

849

PB 390

PREEMERGENT WEED CONTROL IN CONTAINER-GROWN HERBACEOUS PERENNIALS.

James E. Klett*, David Staats, David Hillock, Department of Horticulture, Colorado State University, Fort Collins, CO 80523.

During the 1992 season six preemergent herbicides (Devrinol) at 4.5 and 9.1 kg/ha, Metolachlor (Pennant) at 4.5 and 9.1 kg/ha, Isoxaben (Gallery) at 1.1 and 2.3 kg/ha, Oxyfluorfen + Oryzalin (Rout) at 3.4 and 13.6 kg/ha, Oryzalin (Surflan) at 2.8 and 4.5 kg/ha and Trifluralin (Treflan) at 4.5 and 9.1 kg/ha, were tested on *Rudbeckia fulgida* "Goldstrum", *Digitalis purpurea* "Excelsior", *Chrysanthemum maximum* "Alaska", *Stokesia laevis* "Blue Danube", and Geum hybrids "Mrs. Bradshaw". Gallery at both rates resulted in visual phytotoxicity on *Chrysanthemum*, *Digitalis* and stunting in *Rudbeckia* at the 2.3 kg/ha rate. During the 1993 season the same herbicides plus Oxadiazon (Ronstar) at 4.5 and 9.1 kg/ha, were tested on *Achillea tomentosa*, and *Thymus pseudolanuginosus*. Gallery and Pennant at both rates resulted in visual phytotoxicity and stunted growth on *Thymus pseudolanuginosus*. Rout at the 13.6 kg/ha rate resulted in visual phytotoxicity on *Achilles tomentosa*.

850

PB 393

GROWTH AND DEVELOPMENT OF BITTERCRESS IN AN ORNAMENTAL NURSERY

Gary R. Bachman* and Ted Whitwell. Department of Horticulture, Clemson University, Clemson, SC 29634-0375

Bittercress (*Cardamine hirsuta*) is a nuisance weed in the ornamental nursery industry. Seed formation and dispersal during propagation production at an ornamental nursery were studied. There is much variability in silique number and seed per silique with the means being 77 and 29, respectively after five weeks. Average number of seed produced was 2233 per plant. The seeds are forcefully expelled with a mean distance of 61 cm. Germination of these freshly released seeds was 90% after 13 days with a generation time of nine weeks. Seed source in the nursery was from either the gravel floor or reuse of the propagation containers. Comparing germination of bittercress seedlings in dirty or cleaned containers, use of dirty containers resulted in significantly higher numbers of bittercress seedlings than the cleaned.

851

PB 396

THE EFFECT OF EUCALYPTUS MULCHES ON GERMINATION OF ANNUAL AND PERENNIAL WEED SPECIES.

A. James Downer and Ben Faber

University of California Cooperative Extension 702 County Square Drive, Ventura CA 93003.

Eucalyptus mulch is considered by many horticulturists to be toxic to cultivated plants and weeds. The purpose of this study was to determine the weed suppressive effect of mulch made from various Eucalyptus species. Propagation flats were seeded with 100 seeds each of nine weed species and covered with peat-perlite media, or composted or fresh *Eucalyptus globulus*, *E. citriodora*, *E. rudus*, *E. polyanthemus*, *E.*

sideroxylon, *E. maculata* or *E. ficifolia*. Fresh mulch suppressed germination of all species. Compost mulched weeds seeds germinated more and produced more dry weight than fresh mulch treatments. Barnyardgrass (*Echinochloa crusgalli*) died in all flats treated with fresh *E. sideroxylon*.

852

PB 399

POTENTIAL USE OF OXADIAZON AND SETHOXYDIM FOR THE PRODUCTION OF FOUR WOODY ORNAMENTAL PLANTS GROWN IN CONTAINERS

Driss Iraqi, Isabelle Duchesne* and Jacques André Rioux, Université Laval, Pav. Environtron, Sainte-Foy (Qc) G1K 7P4, Canada.

The objective of this study is to determine the phytotoxicity and efficiency of oxadiazon and sethoxydim used as herbicide in the production of four species of woody ornamental plants grown in containers. Four species were used: *Cornus alba* 'Argenteo Marginata', *Weigela florida* 'Rumba', *Prunus x cistena* and *Thuja occidentalis* 'Woodwardii'. Six herbicide treatments were used (oxadiazon at 0, 4 and 8 Kg (a.i.)/ha; sethoxydim at 0.000, 0.276 and 0.552 Kg (a.i.)/ha) and two controls were added (weeding and unweeding). The eight treatments were included in a complete block design replicated six times. This project was started in July 1993 and was conducted for three months. If phytotoxic symptoms were present on plants they were recorded and their effects on growth was measured. At the end of the experiment, weeds present in pots were identified, counted and their growth measured. Preliminary results showed that oxadiazon applied at rates of 4 and 8 Kg (a.i.)/ha had a good efficiency weed control in container production. Sethoxydim applied at rates of 0.276 and 0.552 Kg (a.i.)/ha had a good grass control. The two herbicides did not show phytotoxic symptoms on the for species used. The effects of herbicides on plant growth will be presented.

853

PB 422

USING POTENTIAL OF COPPER TO CONTROL THE ROOTS CIRCLING OF TREES CONTAINER PRODUCTION.

Driss Iraqi, Isabelle Duchesne* and Jacques-André Rioux, Université Laval, Pav. Environtron, Sainte-Foy (Qc), G1K 7P4, Canada.

Root system growth in limited volume containers can have important consequences on stem growth and root morphology. The most widespread deformation observed is root circling. Consequently, root circling often reduces growth, root regeneration and tree anchorage at transplanting time. The objective of this study is to restrict root tips. Three tree species were used in the study; *Fraxinus pennsylvanica*, *Acer saccharinum* and *Malus baccata*. All species were grown in containers lined with one of six combinations of polymer (P) (0, 30 and 60 g/m²) and copper (Cu) (0, 0.4 and 0.8%) coated fabric. Two other treatments were included as controls: a plastic container and a fabric container. Treatments were randomized in complete blocks with six repetitions. Preliminary results of root circling length and dry weight indicate good restriction of root tips for two combinations (30 g of P/m² - 0.8% Cu; 60 g of P/m² - 0.8% Cu) for all species. However, treatments did not cause any reduction in stem height, trunk diameter or stem and root dry weight. Phytotoxic symptoms were not observed throughout the experiment.

854

PB 425

CHEMICAL ROOT PRUNING OF CONTAINER-GROWN TREES USING TRIFLURALIN AND COPPER IMPREGNATED FABRIC.

Steven E. Newman* and Jesse R. Quarrels, Department of Plant and Soil Sciences, Box 9555, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS, 39762.

Many nurseries are using the pot-in-pot (PNP) system to grow trees in containers. This system protects the roots from temperature extremes and prevents tipping. PNP is not without problems, trees with vigorous roots may escape the container and root into the external soil making harvest difficult. PNP has no effect on root circling. Our objective was to determine if a polypropylene fabric disk treated with either trifluralin or copper placed in the bottom of a container would prevent root circling. *Cercis canadensis* and *Quercus shumardii* seedlings were grown in 19 liter polyethylene containers with eight root control treatments, which included trifluralin or copper impregnated polypropylene fabric disks placed in the bottom of the containers. Trifluralin treatments, BioBarrier and trifluralin impregnated fabric, had few roots in the bottom of the containers. Of the copper treatments, Spinout® impregnated fabric was the only copper treatment that had any effect on root development in the bottom of the containers.

EFFECTS OF SPIN OUR™-TREATED CONTAINERS ON SHORT TERM LEACHING OF COPPER AND COPPER ACCUMULATION IN RECYCLED IRRIGATION WATER DURING GROWTH OF CORN AND BALDCYPRESS IN SAND OR BARK MEDIA

Larry J. Shoemaker* and Michael A. Arnold, Dept. of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

Zea mays L. and *Taxodium distichum* L. seedlings were grown for 35 days in sand or 3:1 milled pine bark:sand media in 0.7 liter containers. Containers were painted on interior surfaces with 100 g Cu(OH)₂/liter or 200 g Cu(OH)₂/liter latex carrier (Spin Out™) or not. Five seedlings of each treatment combination were watered daily from 9.5 liter reservoirs with 100 ml of recycled fertilizer (20N-8.7P -16.6K. pH 6.0) solution initially containing 0.036 mg Cu/liter. Fertilizer solutions containing 0.036, 5, 10, 100, or 1000 mg Cu/liter were used to develop toxicity response curves with additional seedlings. Growth of both species in both media was increased by Spin Out treatments. Soluble Cu content of the recycled solution from Spin Out treated containers increased slightly (<1.2 mg/liter) during the experiment. Soluble Cu in leachate from Cu-treated containers ranged from 0.2 to 5 mg /liter with sand and from 0.30 to 1.2 mg /liter with bark. Soluble Cu in leachate from non-treated containers ranged from 0.02 to 0.40 mg/liter with sand and 0.10 to 0.86 mg/liter for bark media.

COPPER HYDROXIDE-TREATED POTS IMPROVE THE ROOT SYSTEM OF BOUGAINVILLEA CUTTINGS

James H. Aldrich* and Jeffrey G. Norcini, University of Florida, North Florida Research and Education Center, Rt. 4 Box 4092, Monticello, FL 32344-9302

The response of the root system of 'Barbara Karst' bougainvillea [*Bougainvillea buttiana* (Bougainvillea glabra Choisy x *Bougainvillea peruviana* Humb. & Bonpl.) 'Barbara Karst')] cuttings to 100 g Cu(OH)₂/liter⁻¹ in a white latex paint applied to the interior surface of square 66 ml, 120 ml, or 280 ml plastic pots was determined. Cuttings (10 cm long; 3-5 nodes; 2 leaves) were scored on opposite sides and dipped in 6000 mg·liter⁻¹ KIBA for 3 sec. The cuttings were placed in treated or untreated pots that contained a medium of 1 Canadian sphagnum peat: 1 coarse perlite (v/v). The pots were completely randomized in a 3X2 factorial design. The cuttings were rooted under intermittent mist 9 sec·min⁻¹ for 12 hr·day⁻¹ in a greenhouse (20% shade). The number of primary roots, fresh and dry weights, and root quality were determined 15 June. The Cu(OH)₂-treated pots resulted in a more compact, well-branched root system and eliminated root circling. However, root fresh weight was reduced by Cu(OH)₂ treatment. Pot size influenced the number of primary roots and fresh and dry weights.

at 8 week intervals after transplanting to 9.5-liter containers. Plant growth and phytotoxicity were evaluated 0, 4, and 8, and 1, 2, 4, and 8 weeks after application, respectively. Dikegulac-sodium at 3200 mg·liter⁻¹ was the optimum treatment for suppressing the lateral growth of Asiatic jasmine and the vertical growth of confederate jasmine with minimal phytotoxicity. Dikegulac-sodium at 4800 mg·liter⁻¹ excessively inhibited growth of both species and resulted in unacceptable phytotoxicity. All maffluidide treatments had minimal growth inhibitory effect on either species.

ANTIDESICCANTS APPLIED TO PACKAGED ROSE PLANTS AFFECT GROWTH AND FIELD PERFORMANCE

John F. Karlik* and Ursula K. Schuch, University of California, Cooperative Extension, 1031 S Mt. Vernon Ave., Bakersfield, CA 93307 and Botany and Plant Sciences Dept., Riverside, CA 92521

Moisture loss from bare-root plants during postharvest handling and storage can have a significant effect on plant growth and survival during establishment. Three film-forming antitranspirants and hot wax were applied to bare-root roses packaged after harvesting from the field and before three months of cold storage to determine effects on vegetative growth and flowering. Subsequently, during three weeks under display conditions, plants treated with hot wax resumed growth at the fastest rate compared to control or antitranspirant treatments. Hot wax-treated plants continued to grow at a faster rate than the other plants for two weeks following transplanting in the field. For the remaining 10 weeks of the experiment no differences in vegetative growth or flowering development were found between treatments. Over 70% of the plants treated with hot wax became sunburned, resulting in severe cane damage and plant dieback. Less than 20% of the plants from the other treatments were damaged.

IRON DEFICIENCY STRESS INFLUENCES PHYSIOLOGY OF IRON ACQUISITION IN MARIGOLD (*T. erecta* L.).

Joseph P. Albano* and William B. Miller*, Clemson University, Dept. of Horticulture, Clemson, SC. 29634-0375

Marigolds under iron deficiency stress exhibited characteristics associated with iron efficiency (e.g. induced reductase and rhizosphere acidification). Ferric reduction rates for roots of the minus Fe-DTPA treatment group was 0.97 $\mu\text{mol} \cdot \text{g} \cdot \text{FW}^{-1} \cdot \text{h}^{-1}$, 14 times greater than the 17.9 μM Fe-DTPA treatment group. Excised primary lateral roots from the minus Fe-DTPA and 17.9 μM Fe-DTPA treatment groups embedded in an Fe reductase activity gel visually confirmed an increased Fe reduction rate for the minus Fe-DTPA treatment group. The pH of the nutrient solution one week after initiation of treatments indicated that the minus Fe-DTPA treatment group was 1 pH unit lower than the 17.9 μM Fe-DTPA treatment group at 4.1 and 5.1, respectively.

176 POSTER SESSION 24 (Abstr. 860-869) Herbs

GROWTH RESPONSES OF CULANTRO (*Eryngium foetidum* L.) TO GIBBERELIC ACID SPRAYS

Christopher Ramcharan, University of the Virgin Islands, Agricultural Experiment Station, RR 02, P.O. Box 10000, Kingshill, St. Croix, USVI 00850.

Culantro, an umbelliferous aromatic saponin-containing biennial herb native of Central America and the West Indies is a major ingredient of many West Indian and Latin American dishes. Although closely related to the Asian culinary herb - cilantro or coriander, culantro is mainly prized for its green serrate spatulate-shaped leaves the main source of its oil. Like many other umbelliferoids under high temperatures and long summer days of the tropics culantro produces large umbel inflorescences and seedheads which are labor-intensive to remove, retard leaf growth and hence decrease the market value of the plant. Preliminary studies using ProGibb sprays from 50 to 200 ppm to 3- to 4-month old culantro plants grown under 53% shade showed increased leaf growth and chlorophyll content response

ROOT DISTRIBUTION OF SIX PALM SPECIES GROWN IN CUPRIC HYDROXIDE-TREATED CONTAINERS

Sven E. Svenson* and Timothy K. Broschat, Fort Lauderdale Research and Education Center, University of Florida, 3205 College Avenue, Fort Lauderdale, FL 33314.

The root distribution of seedlings of *Acoelorrhapha wrightii*, *Carpentaria acuminata*, *Chrysalidocarpus lutescens*, *Livistona chinensis*, *Phoenix roebellenii*, and *Washingtonia robusta* were grown in nontreated containers or in containers treated on their interior surfaces with 25, 50 or 100 g Cu(OH)₂/l. Seedlings of all species grown in treated containers had reduced circling or matted roots at the container wall-growing medium interface. The distribution of root dry weight and root length was species specific, and was significantly influenced by the rate of copper hydroxide applied. Copper treatment did not induce visual signs of copper toxicity, nor differences in shoot growth, nor differences in the number of higher-order lateral roots.

EVALUATION OF DIKEGULAC-SODIUM AND MEFLUIDIDE FOR GROWTH CONTROL OF ASIATIC AND CONFEDERATE JASMINE

Jeffrey G. Norcini* and James H. Aldrich, University of Florida, North Florida Research and Education Center, Rt. 4 Box 4092, Monticello, FL 32344-9302

The effectiveness of three concentrations of either dikegulac-sodium or mefluidide on the growth of two containerized woody vine crops was investigated. A single application of dikegulac-sodium at 1600, 3200, or 4800 mg·liter⁻¹ or mefluidide at 600, 1200, or 1800 mg·liter⁻¹ was applied to either 3.8-liter containers of Asiatic jasmine (*Trachelosperum asiaticum* Siebold and Zucc.) or staked confederate jasmine (*Trachelosperum jasminoides* (Lindl.) Lem.) on 25 May 1993. Two additional applications were made

to increasing levels of ProGibb. Maximum leaf length, fresh leaf weight, chlorophyll content and decreased flower growth were obtained at 100 ppm spray application. Treated plants remained in a vegetative phase for almost two years when vegetative side shoots were established. Postharvest observations showed no apparent decrease in shelf life nor loss of characteristic leaf aroma in leaves harvested from GA-treated plants. Inflorescences from sprayed plants were highly reduced in size, had leaf-like appearance and produced characteristic culantro aroma indicating that they may also be utilized in culantro cuisines.

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In Vitro Adventitious Shoot Formation and Plant Regeneration from Culantro (*Eryngium foetidum* L.) Leaf Yasseen Mohamed-Yasseen, Department of Horticulture, University of Illinois. 61801.

Culantro is a perennial herb with odor like that of coriander, native to tropical America and the West Indies. Explants were excised from leaf petiole of mature culantro plant. Explants were cultured on MS alone or supplemented with 4.4, or 13.3 μ M BA with 0.5 μ M NAA, or supplemented with 0.3, 1.8, 4.5, or 3 μ M Thidiazuron (TDZ) with 0.5 μ M NAA. Leaf explants formed callus and were transferred to the same medium for shoot induction. Only explants which were cultured on MS supplemented with 13.3 μ M BA or 0.9, 1.8, 4.5, or 3 μ M TDZ produced shoots. Shoots were regenerated in all TDZ-containing media with high 100% frequency. Shoot number increased with the increase of TDZ concentration but shoot length decreased. Although cytokinins are reported to inhibit root initiation, regenerated shoots formed roots with 100% frequency in BA- and TDZ-containing media. Regenerated shoots were transferred to MS containing 3.9 μ M TDZ for further growth. Rooted shoots were transferred to soil and normal plants were obtained.

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VARIATION IN MINT GERMPLASM FOR CHEMICAL COMPOSITION M. RAWGAPPA*, H.L. BHARDWAJ, A.I. MOHAMED, M.E. SHOWHDA, AND M.E. KRAEMER, Virginia State University, Petersburg, VA 23806

Thirty-five mint accessions were evaluated during 1993 for agronomic characteristics (leaf texture, color, and pubescence), plant vigor, cold hardiness, insect population interactions, and contents of essential oils, ash, and total protein. These accessions were obtained from National Clonal Germplasm Repository, Corvallis, Oregon during 1992. The rhizomes were planted in the greenhouse on April 2, 1992 and transplanted to the field on May 29, 1992 as a randomized complete block design with three replications. The chemical composition data from whole plants indicated that ash content was dependent upon location from which an accession was collected, ploidy level (diploid vs. polyploid), type of mint (peppermint vs. spearmint), and genetics (hybrid vs. non-hybrid). Diploid accessions had significantly higher essential oil content. The protein content was higher in peppermint types than spearmint types. The hybrid accessions had lower protein content in comparison to non-hybrids.

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SENSITIVITY OF ARTEMISININ YIELD FROM SWEET WORMWOOD (*ARTEMISIA ANNUA*) TO CHANGES IN CULTURAL PRACTICES

Clint C. Shock*, Erik B. G. Feibert and Monty Saunders, Malheur Experiment Station, 595 Onion Ave., Ontario, OR, 97914

Sweet wormwood is a source of the anti-malarial plant secondary compound artemisinin. The effects of water stress, nitrogen rates, plant growth regulators, and harvest timing on vegetative growth and yield of artemisinin were tested in separate experiments. In the harvest timing trial, total biomass, leaf yield, leaf artemisinin content and total artemisinin yield increased during the season. The wettest treatment tested decreased the total plant dry to fresh weight ratio, but had no effect on height, total biomass, leaf yield, leaf artemisinin content and artemisinin yield. Nitrogen fertilization increased plant height, but had no effect on total biomass, leaf yield, leaf artemisinin content and artemisinin yield. The plant growth regulators decreased plant height, increased total biomass, but had no effect on leaf yield, leaf artemisinin content and artemisinin yield. The effects of chemical weed control and post-harvest leaf drying will also be discussed.

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RESPONSE OF *NIGELLIA SATIVA* L. PLANTS TO FERTILIZATION AND GROWTH REGULATOR TREATMENTS. I. VEGETATIVE GROWTH AND SEED YIELD

Ahmed A. Al-Badawy*, Nadia M. Abdalla, Mahmoud A. Hassan and Ahmed F. Ali, Department of Horticulture, College of Agriculture, Minia University, El-Minia, Egypt.

Nigellia sativa L. plants were fertilized with different rates of NPK fertilizers and sprayed with the growth regulators BL-2142 at 0, 250, 500, and 1000 ppm, CCC at 0, 500, 1000, and 1500 ppm and Multiprop at 0.125, 25, and 50 ppm.

The results indicated that both of NPK fertilization and growth regulator treatments enhanced the plant growth in terms of stem diameter, branch number and herb dry weight. Also, these treatments caused early flowering, increased fruit number and seed yield compared to the control plants.

The interaction between NPK fertilization and growth regulators had a synergistic effect. The highest seed yield was obtained when the plants received 200, 100, and 25 kg/feddan (feddan = 4200 sqm) of urea, calcium superphosphate and potassium sulphate, respectively and sprayed with CCC at 500 ppm.

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RESPONSE OF *NIGELLIA SATIVA* L. PLANTS TO FERTILIZATION AND GROWTH REGULATOR TREATMENTS. II. CHEMICAL COMPOSITION

Ahmed A. Al-Badawy*, Nadia M. Abdalla, Mahmoud A. Hassan and Ahmed F. Ali, Department of Horticulture, College of Agriculture, Minia University, El-Minia, Egypt.

Nigellia sativa L. plants were fertilized with different rates of NPK fertilizers in combination with the growth regulators, BL-2142, CCC and Multiprop sprayed at varied concentrations.

Fertilization and growth regulators increased the volatile and fixed oil content in the seeds. The photosynthetic pigments in the leaves, the reducing sugar and the total carbohydrate contents, N, P, and K uptake in the herb were also increased.

The interaction between fertilization and growth regulators had a synergistic effect on increasing the volatile and fixed oil percentage and yield, the photosynthetic pigments, N, P, K uptake. The highest volatile oil yield was found when the plants received 100, 200 and 50 kg/feddan (4,200 sqm) of urea, calcium superphosphate and potassium sulphate, respectively and sprayed with 50 ppm BL-2142, 1000 ppm CCC or 12.5 ppm Multiprop. The volatile oil, fixed oil yield and seed yield were highly and significantly correlated with each other.

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PB 545

PRODUCTION POTENTIAL OF ESSENTIAL OIL CROPS IN SAUDI ARABIA

Mohammed Sarwar* and Saleh A. Al-Namlah, King Khaled International Airport, P.O. Box 12531, Riyadh 11483, K.S.A.

Saudi Arabia is known for arid character and its total unsuitability for any agricultural exploitation. However, it is now proving otherwise with the application of modern agro-technology resulting in large scale production of many crops successfully. Considering the international growing demand of essential oils, need of agrocommunities for new crops, advantages of local warm climate and availability of generous government funding system, essential oil production offers immense potential in Saudi Arabia. This paper intends to describe the prospects of raising *Pelargonium graveolens*, *Mentha arvensis*, *Artemisia pallens*, *Cymbopogon winterianus*, *Cymbopogon flexuosus*, *Ocimum basilicum*, *Eucalyptus citriodora*, *Rosemarinus officinalis*, *Coriandrum sativum*, *Anethum graveolens*, *Jasminum grandiflorum* and *Pogostemon patchouli* successfully at various ecosystems and to establish new agroindustries based on essential oils around the Kingdom.

FLOWERING RESPONSE, SEED OIL, AND VERNOLIC ACID CONTENTS OF *VERNONIA GALAMENSIS* INTRASPECIFIC HYBRIDS

David A. Dierig*, Anson E. Thompson, Earl R. Johnson, and Gail H. Dahlquist, USDA-ARS, U.S. Water Conservation Laboratory, 4331 E. Broadway, Phoenix, AZ, 85040

Vernonia galamensis is a potential new crop for production of epoxidized oil with many industrial applications. This plant is native to equatorial Africa, and not adapted for culture in temperate zones since it requires a short daylength to initiate flowering and subsequent seed development. One collection of *V. galamensis* ssp. *galamensis* var. *petitiana*, flowered freely and produced seeds during long-day conditions throughout the United States. This variety lacks important plant characters for successful commercialization. The favorable genetic recombination of day-neutral response with more desirable plant growth characteristics, desirable seed oil and fatty acid content from other accessions of *V. galamensis* has been accomplished in hybrids and segregating populations, and selections are being widely evaluated throughout the U.S..

IMPROVING SEED GERMINATION OF ANGELICA (*Angelica archangelica* L.)

Lucette Laflamme^{*1,2}, Marie-Hélène Michaud³, and Nicolas Tremblay¹. ¹Agriculture and Agri-Food Canada, Research Station, 430 Gouin Blvd, St-Jean-sur-Richelieu (Que.) J3B 3E6, Canada; ²Bioplant Research Laboratories Inc., Varennes (Que.), Canada.

Angelica is grown in Quebec (Canada) for its root-bound medicinal properties. Matol Botanique Int., a major user of *Angelica* extracts, decided 4 years ago to promote local production in order to secure supplies and quality. However, the crop has to be started from seed that show low and variable germination behavior. Emergence occurs after \pm 12 days and most of the germination if obtained after 20 to 40 days depending on seed origin and test conditions. Maximum germination ranges from 6 to 57%. Three treatments were first compared in order to stimulate germination: seed soaking in warm water for 24 h, watering germination trays with algae extracts and placing floating row covers over the trays. *Angelica* germination was significantly improved only by row covers with a maximum of 24% vs 19%. Results were obtained from experiments with other techniques (stratification, seed conditioning, etc, ...) to further improve germination.

^{*}Working for the Horticultural Research Centre, Laval University, Que.

THE MARKETING OF MEDICINAL PLANTS IN THE VIRGIN ISLANDS: PAST, PRESENT, AND FUTURE PROSPECTS

Toni A. Thomas and Manuel C. Palada, University of the Virgin Islands Cooperative Extension Service, #2 John Brewers Bay, St. Thomas, USVI 00802-9990.

In the U.S. Virgin Islands (USVI) more than 400 plants are recorded as having been used for medicinal purposes. Traditional use of medicinal plants (locally known as "bush") is based on Amerindian, African and European influences. Despite the predominance of "western medicine", many Virgin Islanders still use medicinal plants for self-treatments, beverages and culinary purposes. Traditionally, medicinal plants were either collected growing wild or cultivated and often sold in marketplaces for local consumption. This method of marketing still exists, but new marketing outlets are developing. Selections of popular medicinal plants (imported and local) appear both fresh and packaged dry in supermarkets and specialty shops. Blended brews (i.e. "bush teas") are available in restaurants, bakeries and delicatessens. Creatively packaged products are featured in stores and hotels catering to the tourist trade. Current expanding marketing trends target the great number of tourists visiting the USVI. Future plans with significant impact on marketing include the use of solar driers and establishment of a Fanners' Cooperative.

177 POSTER SESSION 25 (Abstr. 870-901)
Cell and Tissue Culture/PropagationINFLUENCE OF SCARIFICATION AND TEMPERATURE TREATMENTS ON SEED GERMINATION OF *LUPINUS HAVARDII*

Tim D. Davis*, Wayne A. Mackay, and Daksha Sankhla, Texas Agric. Expt. Sta., Texas A&M University Research & Extension Centers, 17360 Coit Rd., Dallas, TX 75252 & 1380 A&M Circle, El Paso, TX 79927

Seeds of Lupinus havardii Wats. (Big Bend bluebonnet), a potential cut flower crop, were subjected to a variety of scarification and temperature treatments. Without scarification, only 10-20% of the seeds germinated within one week. Germination percentages increased sigmoidally as scarification time in concentrated sulfuric acid increased. Nearly 100% germination was obtained within one week after seeds were placed in sulfuric acid for 120 min. Nicking the seed coat with a razor blade also resulted in near 100% germination. Soaking the seed in water for 24 h failed to enhance germination. Soaking the seed in ethanol, methanol, or acetone for 2 h likewise failed to enhance germination. Total germination of scarified seed was >90% between 21 and 33C within 28 h. The most rapid germination occurred within a range of 24-29C. Above or below this range germination was delayed. At 35C, seedling mortality was observed and total germination was reduced to <50%. Our data indicate that seed of this species requires scarification for optimum germination but the seed can germinate over a relatively wide temperature range.

IMPROVED GERMINATION OF PANSY SEED AT HIGH TEMPERATURES BY PRIMING WITH SALT SOLUTIONS

Beyoung-han Yoon*, Harvey J. Lane and B. Greg Cobb, Department of Horticultural Sciences, Texas A&M University, College Station, TX. 77843

Pansy (*Viola x wiffrockiana* cv. Majestic Giant Blue Shades and Crystal Bowl Sky Blue) seeds were primed in various salt solutions at -1.0 MPa for 3, 6 or 9 days at 23C to determine if priming could overcome thermoinhibition at high temperatures (30C and above). Salt solutions tested were KNO₃, KCl, NaCl, MgCl₂, Na₂SO₄, Na₂HPO₄, K₂HPO₄, and CaCl₂, with polyethylene glycol (PEG) serving as a comparison non-salt solution. Total percent germination (G) of non-primed seeds decreased significantly for both cultivars as germination temperature increased from 25C to 35C. Total seed germination and time to 50% germination (TS₅₀) varied widely among the different priming solutions, with all solutions decreasing T₅₀ as compared to non-primed seeds. Seeds primed with PEG for 6 and 9 days, however, germinated during the priming process and were not further examined. Priming did not significantly improve total percent germination versus non-primed seed at 25C. Seeds that had the best G and T₅₀ at temperatures at or above 30C were those primed for 3 days with CaCl₂ (for 'Crystal Bowl' there was a 40% increase in G at 35C), and MgCl₂ (for 'Majestic Giant' there was a 15% increase in G at 35C).

ENHANCED ROOT AND SHOOT GROWTH OF CHRYSANTHEMUM CUTTINGS PROPAGATED IN MEDIA INOCULATED WITH *TRICHODERMA HARZIANUM*

Amy J. MacKenzie*, Terri W. Starman, and Mark T. Windham, Department of Ornamental Horticulture and Landscape Design, Institute of Agriculture, University of Tennessee, Knoxville, TN 37901-1071

Trichoderma harzianum is a well-documented biocontrol agent that has been shown to enhance rooting of chrysanthemum 'White Marble'. The objective of this research was to determine if *T. harzianum* would enhance rooting of hard-to-root chrysanthemum cuttings. Two hard-to-root cultivars ('Dark Bronze Charm' and 'Golden Bounty') and two easy-to-root cultivars ('Davis' and 'White Marble') were propagated in a 1:1 peat-perlite medium amended with *T. harzianum* at a rate of 0, 5, or 25g/kg medium. Measurements were taken 7, 14, and 21 days after insertion of the cuttings into the medium. Interactions occurred between rate of amendment and day of measurement for some variables measured. However, overall there was increased root fresh and dry weight of all cultivars when *T. harzianum* rates were 5 or 25 g/kg medium. Increased root fresh and dry weight occurred on days 14 and 21 for most cultivars. Root fresh and dry weight increased with increasing rate of amendment on day 14 but there was no difference between the 5 and 25 g/kg rates on day 21. Shoot fresh weight was increased with 5 or 25 g/kg each measurement day for all cultivar except 'White Marble' and shoot length was increased with 25g/kg for all cultivars.

ROOTING STUDIES ON POINSETTIAS

Michelle Carratu* and Roger J. Sauve Dept. of Agricultural Sciences, Tennessee State University, Nashville, TN 37209-1561

Several studies were conducted to evaluate the effects of cultivar, cutting length, and leaf number on rooting of poinsettia. Cuttings were rooted under mist in a soilless medium with 50 cuttings per treatment. Visual rootball ratings were performed after 3 wk. In the first experiment, rooting of ten poinsettia cultivars was compared. The rooting hormone was 0.1% indole-3-butyric acid (IBA). Rooting of 'V-14 Red' and 'V-14 Marble' was the highest. 'V-17 Pink' and 'V-17 Marble' had the highest number of callused cuttings. 'V-17 White' produced the highest number of extensively rooted cuttings. 'V-14 Pink' (3-lf) cuttings 12 cm long rooted better than 5 cm cuttings. Rooting of (7 cm) 3- and 4-leaf cuttings was higher than rooting of 2-leaf cuttings. 'V-14 Pink' cuttings treated with 0.8% IBA or 1% IBA + 0.5% 1-naphthaleneacetic acid (NAA) rooted better than with 0.1% or 0.3% IBA.

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STATISTICAL DETERMINATION OF ADEQUATE SAMPLE SIZE AND REDUCTION OF VARIANCE IN TOMATO TISSUE CULTURE

Carol A. Bobisud*, Susan P. Martin, Terry T. Sekioka, Kauai Research Station, 7370-A Kuamoo Road, Kapaa, HI 96746

To estimate the components of variance of a tissue culture experiment, hypocotyl sections of tomato cultivars (C) 'Healani', 'Kewalo' and 'Anahu' were cultured on modified Murashige and Skoog medium with 10 uM IAA and 10 uM BAP. Three explants were placed in each of 45 flasks per cultivar. This procedure was repeated three times (R) on different dates. Mean values of the number of shoots per explant were 7.0, 8.2 and 9.2 for 'Healani', 'Kewalo', and 'Anahu', respectively. The data were transformed by adding 0.5 and then taking the square root of the sum. Components of variance of the transformed data were $\sigma^2_R = 0.01$, $\sigma^2_C = -0.02$, $\sigma^2_{RC} = 0.09$, $\sigma^2_F = 0.22$ and $\sigma^2_E = 1.68$ (error term). The components of variance were used to determine the theoretical variance of the cultivar (treatment) mean. Results indicated that the most efficient method of reducing the error is by increasing the number of explants per flask. Stein's two-stage sample equation determined the number of explants required for a 95% confidence level to be 1613, 807 and 380 to detect differences of 5% 7% and 10%, respectively, of the overall transformed mean.

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PB 235

STUDY ON MECHANISM OF VITRIFICATION OF MALUS HONANENSIS

Sun Qigao-, Beijing Botanic Garden, Institute of Botany, Chinese Academy of Sciences, Xiangshan, Beijing 100093 China

Through author's two years' study, mechanism of vitrification of *Malus honanensis* was conducted in following aspects:

- (1) Factors affecting vitrification;
- (2) Anatomical comparison of abnormal leaves and stems with those of the normal;
- (3) Content of chlorophyll (a.b/T);
- (4) contents of lignin, cellulose, etc;
- (5) Contents of amino acid, protein;
- (6) Isoenzyme of peroxidase, etc;
- (7) Recovery of vitreous plantlets.

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MICROPROPAGATION OF *UNIOLA PANICULATA* L. (SEA OATS) FROM TILLER EXPLANTS

Nancy Phiman and Michael E. Kane. Environmental Horticulture Department, University of Florida Gainesville FL 32611-0670

Beach stabilization by replanting dune species such as *Uniola paniculata* L. (Sea Oats), is an accepted practice to control erosion in the southeastern United States. Increased restrictions on collection of sea oat seed and plant material for propagation is of increasing concern. Development of micropropagation protocols for establishment and production of sea oats from donor plants of known phenotype would be useful for selecting and producing plants with commercially valuable characteristics. Terminal and lateral shoot tips (3 mm wide and 4 mm high) from containerized plants were surface sterilized and established on Linsmaier & Skoog mineral salts and organics supplemented with 87.6 mM sucrose, 2.2 uM benzyladenine solidified with 0.8% TC® Agar. Terminal tiller shoot tips were more responsive than lateral shoot tips. Four monthly subcultures were required for

stabilized shoot multiplication from culture lines established from terminal tiller shoot tips. Shoot organogenesis frequently occurred from the cut leaf surfaces of subcultured shoot clusters. Microcuttings were established *ex vitro* in plug cells containing sand or vermiculite.

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MICROPROPAGATION PROCEDURES FOR *LEONTOCHIR OVALLEI*

Chunsheng Lu*, Yiqin Ruan, and Mark Bridgen, Department of Plant Science, U-67, The University of Connecticut, Storrs, CT 06269

Micropropagation has been used to rescue *Leontochir ovallei*, an endangered Chilean species in the *Alstroemeriaceae*. Cultures were initiated by aseptically germinating seeds of *Leontochir* on a medium containing 1/10 MS salts and vitamins and 0.3% sucrose. Three types of cytokinins (BAP, 2-iP and kinetin) at four concentrations (0, 2, 4, and 8 uM) were studied for shoot proliferation. In the 4 uM BAP treatment, new shoots were produced at an average of six per culture after four weeks of culture. Overall, there was an average of four shoots/culture/4 weeks for all BAP treatments. This was significantly higher than the 2-iP and kinetin treatments. Moreover, the increase of culture fresh weight over time was significantly greater in BAP treatments than those in other treatments. A rooting study compared the effect of NAA and IBA on root initiation. Over 85% of the cultures in 10 and 20 uM NAA treatments produced healthy and large roots. This was significantly higher than the 10 and 20 uM IBA treatments. In summary, a concentration of 4 uM BAP combined with 1 uM IBA in MS salts and vitamins supplemented with 146 mg glutamine/l is the best for shoot proliferation of *leontochir*; an MS basal medium containing 10 uM NAA is the best for root initiation. Micropropagated plantlets have been successfully transplanted into the greenhouse for further genetic and breeding studies.

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PB 264

Micropropagation of pitaya (*Hylocereus undatus* Britt. et Rose)

Yasseen Mohamed-Yasseen, Department of Horticulture, University of Illinois 61801

Pitaya is a member of the family Cactaceae and the genus *Hylocereus* which has several species producing edible fruits. A procedure for micropropagation of pitaya using thidiazuron is described. Explants were excised from young joints of mature plants, and cultured on Murashige and Skoog medium (MS) containing 0.5 uM Thidiazuron (TDZ), and 3.5 uM naphthaleneacetic acid (NAA). Produced shoots were cut longitudinally into three explants or decapitated and cultured on MS supplemented with 0.01, 0.09, 0.5, or 0.9 uM TDZ with 0.5 uM NAA. Decapitated explants produced shoots with higher frequency and number of shoots was higher than 1/3 explants. Shoots produced from decapitated explants were longer, thicker and vigorous, compared to shoots developed from 1/3 explants. Most shoots developed from the distal part in both explants and produced several lateral shoots from axillary buds. Shoots were rooted in MS then transferred to soil and produced normal plants.

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PB 267

Micropropagation of Grand Crinum Lily (*Crinum asiaticum* L.)

Yasseen Mohamed-Yasseen, Department of Horticulture, University of Illinois 61801.

Grand crinum Lily is an ornamental plant which is considered to be one of the architect's favorite accent plants and one that bloom most of the year. A protocol for plant propagation from inflorescence is described. Explants were excised from inflorescence at the primordial stage, and cultured on Murashige and Skoog medium (MS) alone or supplemented with benzyladenine 4.4 or 13.3 uM benzyladenine (BA) and 0.5 uM naphthaleneacetic acid (NAA) and incubated for four weeks. Explants cultured on BA-containing media produced white flower-like structures on the receptacle which produced multiple shoots after additional four weeks on a fresh medium containing 4.4 uM BA and 0.05 uM NAA. Shoots were transferred to a fresh medium for further growth during which the basal stem reached 3 to 5 mm diameter. At this stage shoots, with or without roots, were transferred to soil, without acclimatization, and normal plants were established in soil.

880 PB 270
In Vitro Flower and Plant Formation from *Opuntia dillenii*
Haw. and *Opuntia cochenillifera* Mill.
Yasseen Mohamed-Yasseen, Department of Horticulture,
University of Illinois. 61801.

The genus *Opuntia* includes a number of species which produce nutritious fruits and edible young joints, moreover, they are used as forage crop and for medicinal purposes. A procedure for flower and plant formation is described. Explants were excised from young flower receptacle and cultured on Murashige and Skoog medium (MS) supplemented with 0.9, 1.8, 4.5, or 9 μ M thidiazuron and 0.5 μ M naphthaleneacetic acid. Produced shoots were bisected longitudinally and cultured in a fresh medium from the same composition, other half shoots were subjected to a second cut by dividing transversely into distal and proximal explants before culture. About 80% explants of *O. dillenii* produced flowers which produced shoots from the distal axes. Only shoots were formed from *O. cochenillifera* explants. The distal explants produced more shoots than proximal explants. All formed shoots which attained 3 mm in length or longer were rooted directly in soil and all shoots formed roots and produced normal plants.

881 PB 273
MICROPROPAGATION OF CHIMERAL AFRICAN VIOLETS
Susan D. Schoneweis* and Paul E. Read, University of Nebraska-Lincoln, 377 Plant Science, Lincoln NE 68583-0724.

Chimeral African violets do not come true when propagated from leaf cuttings in conventional or micropropagation systems. Chimeral plants are normally propagated by rooting suckers from mother plants. Premium prices are charged for chimeral plants due to the low numbers produced.

Reports in the *African violet Society Magazine* indicate that chimeral plants can be started by rooting flower peduncles. However, only one or two new plants are generated from each peduncle.

Peduncle tissue was grown *in vitro* to produce large numbers of plants from chimeral African violets. Ratios of plants with true-to-type vs. off-type flowers varied by cultivar and tissue used. The potential use of this technology will be discussed.

882 PB 276
IN VITRO PROPAGATION AND CHIMERAL TRAITS OF *Cryptanthus* 'Marian Oppenheimer' (WIDE LEAF CLONE)
Yong Cheong Koh* and Fred T. Davies Jr., Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

The leaves of vegetative stolons of greenhouse grown *Cryptanthus* 'Marian Oppenheimer' (wide leaf clone) were cultured in modified MS media to induce adventitious shoot formation via callus formation. The best callus induction medium was basal MS medium with 10 μ M NAA, IBA and BA. Pure green (843), maroon (3), striped (2) and albino plantlets were obtained. Most of the albino plantlets were stunted, tightly clumped together and impossible to score. The medium which produced the highest average number of non-albino plantlets was basal MS medium with 0.3 μ M NAA, IBA and BA. All non-albino plantlets were rooted in MS medium with 5.4 μ M NAA and transplanted *ex vitro* with a survival rate of 96.7%. The maroon plantlets became green two weeks after transplanting. Histological studies revealed that *C. 'Marian Oppenheimer'* (wide leaf clone) has two tunics (L1 and L2) and a corpus (L3). Callus on the leaf explant arose mainly from the L2 and L3. Apparently *C. 'Marian Oppenheimer'* (wide leaf clone) is a GWG periclinal chimera.

883 PB 279
REGENERATING ADVENTITIOUS PLANTS FROM IN VITRO CULTURE OF *LIATRIS SPICATA* (L.) WILLD. COTYLEDONS.
Dennis P. Stimart* and John C. Mather, Department of Horticulture, University of Wisconsin, Madison, WI 53706-1590

Cotyledons from developing embryos 6 to 8 weeks old of *Liatris spicata* (blazing star) were cultured on Murashige-Skoog (MS) medium containing 0, 0.4, 4.4, and 44.4 μ M benzyladenine (BA) or 0, 0.2, 2.2, and 22.2 μ M thidiazuron (TDZ) to induce adventitious shoot formation. The highest percent of cotyledons forming shoots with highest shoot counts

was on medium containing 2.2 μ M TDZ. Vitreous shoots formed on medium with 22.2 μ M TDZ. Callus derived from cotyledons and cultured on medium containing 4.44 μ M BA or 2.2 μ M TDZ formed adventitious shoots with highest shoot counts on 4.44 μ M BA. Adventitious shoots derived from cotyledons and callus were rooted on MS medium with 5.0 μ M indole-3-butyric acid, acclimatized and grown *ex vitro*. All micropropagated plants appeared similar to each other.

884 PB 302

PLANT REGENERATION FROM OVARY TISSUES OF EASTER LILY

Jodie L. Ramsay*, Donald S. Galitz¹, and Chiwon W. Lee*,
¹Dept. of Botany, and ²Dept. of Crop and Weed Sciences, North Dakota State University, Fargo, ND 58105

Influences of culture media, sucrose, and growth regulator concentrations on plant regeneration from Easter lily (*Lilium longiflorum* L.) were investigated. Ovary tissues excised from unopened flower buds (3-10 cm long) were cultured on either B-5 medium or MS medium containing 2, 5, or 10% sucrose, 0.8% agar or Phytigel, and varying concentrations of 2,4-D, kinetin, naphthaleneacetic acid (NAA) and benzyladenine (BA). Callus formation from explants was more prolific on MS medium than on B-5 medium and when cultures were initially placed in the dark for 20 days. Cultures grew best when the medium contained 5% sucrose. Shoot differentiation from callus was maximum when MS medium contained 1 mg/liter 2,4-D and 2 mg/liter BA. Roots developed when shoots were placed on the same medium with 1 mg/liter 2,4-D, 0.1 mg/liter NAA and 0.1 mg/liter kinetin. Rooted plants were successfully transferred into soil medium in a greenhouse.

885 PB 305
SOMATIC EMBRYOGENESIS FROM CALLUS OF THE THERMOTOLERANT 'GERMAN RED' CARNATION
Daksha Sankhla, Tim D. Davis,* and N. Sankhla, Texas A&M University Research and Extension Center, 17360 Coit Rd., Dallas, TX 75252-6599

'German Red' is a thermotolerant cultivar of carnation (*Dianthus caryophyllus*) that blooms almost year-round in Texas. This study was initiated to evaluate the feasibility of inducing somatic embryos for use in gene transfer studies and rapid mass propagation. Internodal explants, obtained from microshoots of plantlets cultured on MS medium containing 5 μ M benzyladenine (BA) and 0.5 μ M naphthaleneacetic acid (NAA), were used to initiate callus. Callus formation was induced on MS medium containing 3% sucrose, 0.1% casein hydrolysate and 2,4-D (1-5 μ M) alone or in combination with BA (2 or 4 μ M) or kinetin (2 or 4 μ M). After about 5 weeks, the callus was transferred to either semisolid or liquid MS basal medium with or without kinetin and BA. Within 20-30 days, pro-embryogenic callus masses were observed. The embryos developed from white embryonic tissue and exhibited typical stages of embryogenesis. After 5 weeks, up to 70% of the cultures grown in the liquid medium with or without BA exhibited a profusion of embryo-like structures. Because only a small percentage of these developed into plantlets, more work is needed to enhance conversion frequency.

886 PB 460
SOMATIC EMBRYOGENESIS FROM IMMATURE COTYLEDONS OF TEXAS BLUEBONNET

Daksha Sankhla, Tim D. Davis,* and N. Sankhla, Texas A&M University Research and Extension Center, 17360 Coit Rd., Dallas, TX 75252-6599

This study was initiated to test the embryogenic potential of immature cotyledons (3-5 mm long) of Texas bluebonnet (*Lupinus texensis*). The embryo initiation medium consisted of B5 salts and vitamins with 3% sucrose and 22.6 μ M 2,4-D alone or in combination with 1-15 μ M of various cytokinins. Within 15-20 days, globular embryos were formed on the distal end of the cotyledons. Eventually the entire cotyledon surface was covered by embryo-like structures. Addition of cytokinins to the medium did not increase the percentage of cultures which formed embryos. In fact, addition of thidiazuron severely inhibited embryogenesis. Following transfer to an embryo maturation medium (MS medium with 0.38 μ M abscisic acid alone or in combination with benzyladenine or zeatin) for 10-14 days, the embryos were placed in MS medium supplemented with GA₃ (2.9 μ M) or glutamine (200 mg/liter) with or without activated charcoal (0.5%) for embryo germination and plantlet development. Most of the embryos exhibited precocious germination and well-developed roots but failed to produce normal shoots. Therefore, additional work is needed to improve embryo conversion frequency.

887 PB 463
SOMATIC EMBRYOGENESIS FROM ROSE LEAF EXPLANTS
Mary W. George* and Robert R. Tripepi, Plant Science Division, University of Idaho, Moscow, ID 83844-2339

Previous reports of somatic embryogenesis on rose tissues involved an embryogenic callus stage with either a complicated multi-step process or low numbers of embryos being produced. We have produced somatic embryos without a callus stage from leaf explants of the cut rose cultivar 'Golden Emblem' by using a two step process. Explants were obtained from microshoots of 'Golden Emblem' that had been in culture for three years. All experiments were repeated twice. When explants were maintained on Murashige and Skoog (MS) with 0.4 μ M NAA and 0.4 μ M kinetin for 10 weeks, 10% or less of the explants produced somatic embryos. Keeping the explants on the NAA/kinetin medium for two weeks, then switching to medium with 0, 0.5, 1.0, or 10.0 μ M kinetin for the remaining 8 weeks failed to increase embryo production. Decreasing the time the explants were on the NAA/kinetin medium to 8 or 12 days, and then placing explants on MS medium with 1.0 μ M kinetin increased somatic embryo production to a maximum of 25%. By limiting the length of time the rose leaf explants were exposed to auxin, direct somatic embryo production was increased.

888 PB 466
SEGREGATION OF CHIMERAL APPLES INTO THEIR COMPONENT GENOTYPES IN VITRO.
Orlando McMeans* and Robert M. Skirvin, University of Illinois, Department of Horticulture, Urbana, IL 61801

To isolate unique fruit colors and look for somaclonal variation among regenerants, a regeneration protocol was established for various cultivars of striped apples ('Mailing 26', 'Mutsu', 'Regal Gala', 'Summerland Red', and 'Fuji'). Leaves were harvested from in m-grown plants, transferred to regeneration media [MS + NAA (5.4 μ M) + TDZ (3 μ M)], stored in the dark for 3 to 4 weeks, then moved to controlled light conditions, where adventitious shoot regeneration was observed. Developing shoots were transferred to proliferation medium and screened for their red or green phenotype by placing them on MS media containing various concentrations of sucrose (30, 45, 60, 75 and 90 g/L) and BA (0, 2.5, 5, 7.5, 10, 12.5 and 15 μ M). Some of the regenerated apple shoots exhibited red color soon after being taken from the dark treatment. Others were less distinct, with colors ranging from dull green to a green-pink mixture. The red and green shoots are now being rooted and will be transferred to the field, where they will be grown to maturity.

889 PB 469
IN VITRO SELECTION FOR DWARFISM IN APPLE
Mushtaq Sarwar* and Robert M. Skirvin, University of Illinois, Department of Horticulture, Urbana, IL 61801

Adventitious shoots were regenerated from apple ('Wijcik', 'McIntosh', 'Macspur', 'M-26' and 'Mutsu') by excising leaves from in vitro-grown shoots, cutting them into three sections, and plating them onto regeneration media. Cultures were kept in the dark for 1 to 4 weeks and then moved to light for further shoot development. MS medium supplemented with thidiazuron (2-3 μ M) and naphthaleneacetic acid (5 μ M) produced the highest number of shoots per leaf segment. 'Wijcik' and 'M-26' regenerated best from big leaves, whereas 'McIntosh' and 'Macspur' regenerated best from small leaves. Shoot formation was enhanced by 3 to 4 weeks of dark treatment and by placing the leaf on medium with its abaxial surface uppermost. The cut surface of leaf segments produced the most regeneration sites. In vitro adventitious shoots were transferred to various concentrations of BA (5, 10, 15, 20, 25 and 30 μ M) to screen them for BA tolerance and to predict their adult growth habit. These shoots will be rooted and transferred to greenhouse and field conditions for long-term evaluations.

890 PB 472
SOMACLONAL VARIATION IN PINEAPPLES
Susan P. Martin*, Carol A. Bobisud, and Terry T. Sekioka, Kauai Research Station, University of Hawaii, 7370-A Kuamoo Rd., Kapaa, HI 96746

The objective of this project is to propagate disease-free clones of fresh market pineapples for growers. To expedite the distribution process, sterile cultures were obtained from the

USDA/ARS Germplasm Repository, Hilo, Hawaii of pineapple clones 119, 155 and 159. Plantlets were placed on modified Murashige and Skoog (MS) medium with one half of the salts and 2 μ M BAP and 1 μ M IAA. The cultures were transferred to modified MS medium with one half of the salts, no growth regulators, and solidified with Phytagel. Plantlets were transplanted at one-inch size into peatlite mix. At 4-6 inch size, the plants were transplanted in growers fields. Early observations indicate difference between clones in kinds and frequency of "off-types." Compared with surrounding plants, "off-types" were categorized as being dwarfed, variegated, thorny leaved, and pigmentation modified.

TOWARDS GENETIC TRANSFORMATION OF QUINCE AND PEAR
Sumontip Bunnag*, Ruth C. Martin, David W.S. Mok, and Machteld C. Mok, Dept. of Horticulture, Oregon State University, Corvallis, OR 97331-7304

Quince (*Cydonia oblonga*) is widely used as a dwarfing rootstock for pear (*Pyrus communis*). We have devised procedures for Agrobacterium-mediated gene transfer using leaf discs of quince. The following factors were particularly important for recovery of shoots after incubation of leaf discs with *Agrobacterium*: an efficient regeneration system, the use of an effective antibiotic to eliminate *Agrobacterium* while maintaining a high regeneration frequency, and the choice of selectable markers. The regeneration frequency of control leaf discs on a medium containing 30 μ M thidiazuron and 0.3 μ M naphthaleneacetic acid was 100%. The frequency decreased linearly with increasing concentrations of antibiotics. Timentin, which consists of ticarcillin and a 6-lactamase inhibitor, was more effective in eliminating *Agrobacterium* than cefotaxime and carbenicillin. Vectors with the bar gene (bialaphos resistance) were better than those with the npt II gene (kanamycin resistance), since kanamycin bleached the leaf discs, resulting in poor regeneration. Bialaphos-resistant quince shoots which were positive in Southern hybridization have been obtained. The same procedures are being applied for transformation of pear.

892 PB 496
RESPONSE OF THREE JUGLANS SPP. TO KANAMYCIN AND BIALAPHOS
Lynn M. Long*, John E. Preece, Gerald R. Gaffney, J.W. Van Sambeek, and David A. Lightfoot
Departments of Forestry, Plant and Soil Science, and USDA Forest Service; NCFES, Southern Illinois University, Carbondale, IL 62901-4415

Genetic transformation studies are aided by use of selection agents, such as antibiotics or herbicides. To determine the level of kanamycin to be used as a selection agent, cotyledonary stage somatic embryos from *J. nigra* lines J26 and J28, *J. nigra* x *J. hindsii* line S11, and *J. regia* line SU2 were placed on gelrite solidified WPM with 1 g/liter casein hydrolysate and 250 mg/liter cefotaxime and 3% (w/v) sucrose. Dosages for inhibiting secondary embryogenesis were 40 mg/liter kanamycin for *J. nigra* and *J. nigra* x *J. hindsii* and 100 mg/liter for *J. regia*. For the bialaphos experiments, somatic embryos of *J. nigra* lines J26 and J28 and *J. nigra* x *J. hindsii* line S11 were cultured on gelrite solidified LP medium with 0.5 g/liter casein hydrolysate and 3% (w/v) sucrose. Between 0.1 and 1.0 mg/liter bialaphos, inhibited secondary embryogenesis.

893 PB 499
HIGH FREQUENCY REGENERATION FROM THE LEAF OF *CAPSICUM ANNUUM* L. CV. CHUNGHONG
Young Goel Shon, Joong Choon Park and Byoung Ryong Jeong*, Department of Horticulture, Gyeongsang National University, Chinju 660-701. Korea

Effect of combination and concentration of growth regulators on the regeneration of pepper plant from different explant tissues was studied. Seedlings were grown aseptically in 400 ml glass bottles containing MS agar medium at 26 \pm 2C under a 16 h.d⁻¹ photoperiod (2000 lux, florescent lamps). Explants taken from 4 week-old seedlings were cultured under these conditions on 40 ml of MS agar (8 g.liter⁻¹) medium containing 3 g.liter⁻¹ sucrose in a 400 ml glass bottle. Primary and subsequent leaves attached to petiole regenerated better than cotyledon and hypocotyl. Among the combinations of different concentrations of cytokinin and auxin added in the medium, a combination of 5 μ M IAA with

either 10 μM zeatin or 10 μM BA gave the best regeneration. With these combinations, regeneration frequency of multiple shoots from the primary and subsequent leaves was greater than 70%. Regenerated shoots rooted readily in MS agar medium containing 3 g \cdot liter $^{-1}$ sucrose and 0.5 μM NAA.

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PB 502

COMPARISON OF TWO CULTURE VESSEL ENCLOSURES ON THE GROWTH OF POTATO IN VITRO
N.C. Yorl^o*, C.L. Mackowiak. B.V. Peterson. and R.M. Wheeler, The Bionetics Corporation (ncy, clm, bvp) and NASA Biomedical Operations Office (rmw), Kennedy Space Center, FL 32899.

In vitro growth of white potato (*Solanum tuberosum* L.) cv. Norland was investigated comparing two types of culture vessel enclosures. Nodal cuttings were aseptically transferred to 25 x 150 mm glass culture vessels containing a solidified medium consisting of Murashige and Skoog salts, 1% sucrose, and pH adjusted to 5.8. The vessels were capped with loose-fitted (1 cm gap between the top of the vessel and the top of the cap) Magenta 2-way caps or Bellco Kap-uts with calculated air changes hr $^{-1}$ of 2.25 and 1.43, respectively. Instantaneous PPF attenuations of 15% for Magenta caps and 23% for Bellco caps were also measured. The cultures were maintained for 28 d in an environmental growth chamber under Daylight fluorescent lamps with a 16 hr light/8 hr dark photoperiod, 200 $\mu\text{mol m}^{-2}\text{s}^{-1}$ PPF maintained for each cap type, constant 23 C, 65% relative humidity, and CO $_2$ enrichment of 1000 $\mu\text{mol mol}^{-1}$ external to the culture vessels. Results showed that increased plantlet height, fresh weight, and dry weight was obtained for plantlets cultured with Magenta caps. The differences in growth and internal CO $_2$ concentration of the vessels correlated well with the difference in air exchange rates, suggesting that increased air exchange of culture vessels resulted in increased mixotrophic plantlet growth.

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PB 505

STRATIFICATION OF AMERICAN GINSENG SEED

John T. A. Proctor*, Department of Horticultural Science, University of Guelph, Guelph, Ontario, Canada, N1G 2W1.

American ginseng is propagated by seed. In commercial practice ginseng seed is harvested in August or September, placed in a stratification box for about 12 months, and then direct seeded into raised beds. Germination takes place the following spring, some 18 to 22 months after seed harvest. Little is known about the dormancy-controlling mechanisms of ginseng seed. The objective of this study was to investigate seed development and temperature in the stratification box until it was removed 12 months later and seeded in the field. During stratification 3 embryo growth stages were identified. In Stage I of 250 days (September to mid-May) embryo length increased from about 0.5 to 1.0 mm, in Stage II of 100 days (mid-May to late August) length increased to 2.0 mm and in Stage III (late August to late November) length increased to 5.3 mm. Exocarp split width could also be placed in 3 stages. Changes in embryo length correlated with values for embryo: endosperm length ratio. The stratification box temperatures at all depths never exceeded -2°C even when the air temperatures dropped to -13°C and, therefore, were not damaging to the seeds.

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PB508

A NOVEL METHOD OF AUXIN APPLICATION STIMULATES ADVENTITIOUS ROOT FORMATION IN WALNUT

James R. McKenna* and Ellen G. Sutter, Department of Pomology, University of California, Davis, CA 95616

The use of auxin-impregnated toothpicks stimulated adventitious root formation in genotypes of *Juglans* 'Paradox' that had been backcrossed to *J. regia*. These genotypes were selected as potential rootstocks because of improved tolerance to cherry leaf roll virus and *Phytophthora spp.* Other auxin applications including quick dips and talc formulations had little or no effect. The use of toothpicks lowered the concentration of IBA necessary for root initiation compared to previously reported results using quick dips. Toothpicks were inserted transversely into holes drilled 1 to 2 cm above the base of cuttings. Callus and roots always formed at the location of the toothpicks rather than at the base of the cutting. Roots were formed using this method in simple layering, hardwood, and semi-hardwood cuttings. Of all the cuttings that rooted, 90% rooted with toothpicks whereas only 10% rooted using a quick dip. This method may have potential for increasing the efficiency of rooting other difficult-to-root plants.

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PB 511

ACCLIMATIZATION AND SUBSEQUENT GAS EXCHANGE, WATER RELATIONS, AND GROWTH OF MICROCULTURED APPLE SHOOTS AFTER TRANSPLANTING.

Juan C Dfaz*, Kenneth Shackel and Ellen Sutter, Department of Pomology, University of California, Davis, CA 95616.

Apple plantlets were cultured in a MS medium with agar and transplanted to a soilless mix. Before transplanting, plantlets were acclimatized in a chamber where humidity was linearly decreased from 99% to 75% (21 C) over a period of four days. Gas exchange measurements were made at 95% RH (21 C) and at an irradiance of 350 $\mu\text{mol m}^{-2}\text{s}^{-1}$. Leaf conductance (g $_l$) was measured with a porometer and net photosynthesis (P $_n$) with an IRGA. At the end of the gas exchange measurements, shoot relative water content (RWC) was determined. The results showed that plant water status was an important factor for plant survival and growth after transplanting. Acclimatization before transplanting allowed the plant to maintain a higher RWC, probably because of a better stomatal control of transpiration. Such higher water status was associated with higher growth rates in acclimatized than in non-acclimatized plants. There was a positive correlation of RWC with both a and P $_n$. Transplanted plants had higher values of g $_l$ and P $_n$ compared to in vitro plantlets. Photosynthesis of in vitro plantlets was limited by both stomatal and nonstomatal factors.

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PB 532

LIGHT COMPENSATION POINT AND LOW TEMPERATURE AS STORAGE ENVIRONMENTS OF TRANSPLANTS

Chieri Kubota* and Toyoki Kozai, Faculty of Horticulture, Chiba University, Matsudo, Chiba 271, Japan

A storage method of transplants in vitro was developed using light compensation points in conjunction with low temperatures. Broccoli (cv. Ryokurei) plantlets, aseptically germinated and cultured for three weeks in vitro, were used as model transplants. Culture conditions were: 23C air temperature, 160 $\mu\text{mol m}^{-2}\text{s}^{-1}$ PPF, and 3.6 air exchanges per hour of the vessel. Prior to storage, light compensation points were determined at 3, 5, 10, and 15C for the plantlets cultured with or without 20 g liter $^{-1}$ sugar in the medium. Plantlets were stored for six weeks at 5, 10, and 15C under either 0 or 2 $\mu\text{mol m}^{-2}\text{s}^{-1}$ continuous PPF. The light compensation points varied with air temperature and with medium sugar level. Plantlet dry weight during storage was best maintained by keeping CO $_2$ exchange rate of the plantlets close to zero throughout the storage period. High transplant qualities were successfully preserved at light compensation points: 2 $\mu\text{mol m}^{-2}\text{s}^{-1}$ PPF at 5-10C without sugar, and at 5C with sugar in the medium. This method may be applicable for storage of other crop transplants, plug seedlings and cuttings as well.

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PB 534

MICROPROPAGATION OF ILIAMNA REMOTA, KANKAKEE MALLOW

Sherry L. Hilscher* and John E. Preece, Department of Plant and Soil Science, Southern Illinois University at Carbondale, Carbondale IL 62901

Kankakee mallow is an endangered herbaceous perennial that is indigenous to Kankakee County, Illinois. Stock plants were from seeds pretreated in 82°C water prior to greenhouse germination and growth. Nodal explants were disinfested and placed in vitro onto agar-solidified MS medium containing 0, 0.1, 1.0, 5.0, or 10.0 μM BA and 1.0 μM IBA. Axillary shoots grew and elongated best when the medium contained no cytokinin. BA tended to result in a rosette pattern of leaves. Within hours of placing the original explants in vitro and shortly after subsequent transfers were made (even when there was no cutting) a bright pink exudate appeared in the medium. The most vigorous cultures tended to form the most exudate. Microshoots were placed in a high humidity container in vermiculite wetted with water. Rooting was 50% without auxin. Plants were transplanted into pots containing peat-lite medium and successfully acclimatized to the greenhouse.

FORCING METHOD AND ROOTSTOCK AFFECT SCION BUDBREAK AND GROWTH OF CITRUS NURSERY TREES

J.G. Williamson* and B.E. Maust, Dept. Horticultural Sciences, University of Florida, Gainesville, FL 32611.

Two experiments were conducted to determine the effects of bud forcing method and rootstock on scion budbreak and nursery tree growth of 'Han-din' orange (*Citrus sinensis* Osb.) In Expt. 1, Carrizo citrange [*Citrus sinensis* (L.) Osb. x *Poncirus trifoliata* (L.) Raf.] (Ca), Swingle citrumelo [*C. paradisi* (L.) Osb. x *P. trifoliata* (L.) Raf.] (Sw), and Cleopatra mandarin (*C. reticulata* Blanco) (Cl) were budded with 'Hamlin' orange and forced by cutting off the rootstock tops, lopping (cutting half way through the rootstock stem above the scion bud), or bending the rootstock top and tying it to the trunk). For Cl and Ca percent budbreak was high for all forcing methods. For Sw percent budbreak was greater for cutting off than for lopping or bending. For Sw and Ca, bending or lopping resulted in greater whole plant and scion dry weights than cutting off. Expt. 2 was similar to Expt. 1 except that bending was used alone, or in combination with notching (cutting an invertal v-shaped notch above the scion bud), or with topping the bent rootstock shoot. Scion budbreak of Sw plants was greater for bending + notching than for bending alone. Other effects of rootstock and forcing method for cutting off, bending or lopping were similar to those found in Expt. 1.

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PB 538

STUDIES ON PROPAGATION OF GLOBE ARTICHOKE THROUGH TISSUE CULTURE TECHNIQUE

*Okasha, Kh. A. & Ragab, M. E.

Strawberry Improvement Center, Faculty of Agric.
Ain Shams Univ, Cairo, Egypt FAX 5721628

The aim of this study was to establish an effective method of micropropagation of globe artichoke from shoot-hp. This study involved establishment of an aseptic culture, multiplication of proliferated shoot, rooting of these shoot in vitro and adaptation of plantlets for free living

Highest survival percentage with no contamination was achieved after sterilizing the explants with 70% ethanol (5 Sec.) + 1.5 % sodium hypochlorite for 20 min.

The best results of preventing browning of explants were obtained with 100 mg/l ascorbic acid.

The highest proliferated shoot were obtained when shoot tip with 4 mm length (taken in mid March) were cultured on MS medium with 10mg/l Kin. + 0.5 mg/l IAA.

The highest multiplication rate was obtained when recultured on MS medium supplemented with 5 mg/l Kin. + 0.5 mg/l IAA.

Multiplication rate gradually increased with increasing number of subculturing till the third subculture but subsequent subculture (4th subculture) had a low rate.

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PB 517

CHANGES IN THE ACTIVITIES OF CATALASE, PEROXIDASE, AND SUPEROXIDE DISMUTASE DURING CHILLING STRESS IN ZUCCHINI SQUASH

Chien Yi Wang, Beltsville Agricultural Research Center, Agricultural Research Service, USDA, Beltsville, MD 20705-2350

The activities of catalase and superoxide dismutase decreased while peroxidase activity increased in zucchini squash (*Cucurbita pepo* L., cv. 'Elite') during storage at 5°C. Preconditioning of squash at 15°C for 2 days prior to the cold storage reduced the decline of catalase activity and suppressed the increase in peroxidase activity. The superoxide dismutase activity remained higher in temperature conditioned squash than in untreated squash. These results indicate that acclimation to chilling temperature in squash may also involve modifications in the activities of catalase, peroxidase, and superoxide dismutase.

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PB 520

LIPID COMPOSITION IN SWEETPOTATO (*Ipomoea batatas* L. Lam) STORAGE ROOTS RELATED TO CHILLING TOLERANCE

Chana Phromtons and J. O. Garner, Jr.*, Mississippi State University, Box 9555, Miss. State, MS 39762

Storage roots of 'Beauregard' and Centennial' were analyzed for total fatty acid composition and fatty acid composition by lipid class. The glycolipid, monagalactosyldiglycerol, may have been involved in chilling tolerance of 'Beauregard' storage roots. This lipid had over 70 percent low-melting point fatty acids, mostly linoleic acid and linolenic acid. No consistent differences in the composition of phospholipids could be related to the chilling responses of the two sweetpotato cultivars.

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PB 523

THE IMPACT OF THAW RATE AND POST-THAW LIGHT INTENSITY ON FREEZE-THAW INJURY IN POTATO SPECIES

Laurie S. Weiss and Jiwan P. Palta

Dept. of Hort., 1575 Linden Dr. Univ. of Wisc.-Madison, Madison, WI 53706

At the University of Wisconsin Biotron facility potted plants of *S. tuberosum* were frozen slowly (cooling rate of 1°C/h) to -2°C. Following thaw, plants were subjected to either high light (400 $\mu\text{mol m}^{-2}\text{s}^{-1}$) or low light (100 $\mu\text{mol m}^{-2}\text{s}^{-1}$). High light caused greater damage which appeared as bleaching of the upper leaves in 2 days following thaw. In another study excised paired leaflet halves of *S. tuberosum* and *S. commersonii* were subjected to damaging but sublethal freezing temperatures and thawed either fast (on ice) or slowly (1°C/h). Membrane damage (% ion leakage) was about 2x higher at fast thaw as compared to slow thaw in both cold acclimated and non acclimated tissue. There was greater photosynthetic impairment at slow thaw rate than fast in the non acclimated state, but following acclimation fast thaw was more damaging to photosynthetic function. Respiration in general was less sensitive to freeze-thaw stress as compared to photosynthesis and cell membranes.

Our results show that we could benefit from taking into consideration thaw rate and post-thaw light intensity in developing frost protection plans.

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PB 526

DIFFERENTIAL EXPRESSION OF DEHYDRIN (47 KD) "BOILING STABLE" PROTEIN WITHIN POPULATIONS OF TWO DIPLOID POTATO SPECIES SEGREGATING FOR COLD TOLERANCE AND ACCLIMATION CAPACITY

Bjorn H. Karlsson, Jiwan P. Palta, Laurie S. Weiss, James F. Harbage and John B. Bamberg Dept. Hort., 1575 Linden Dr. Univ. Wisconsin, Madison, WI 53706

Cold-induced changes in gene expression have been demonstrated in a number of species that vary in freezing tolerance and acclimation capacity. Relative freezing tolerance was measured based on ion leakage for both nonacclimated and acclimated *S. commersonii* and *S. cardiophyllum* parents, F1 and backcross progeny segregating for cold tolerance and acclimation capacity. Western blot analyses showed increase in a dehydrin band (47 kD) (antisera courtesy of T. Close) following cold acclimation of cold tolerant *S. commersonii*, and a slight increase in cold sensitive *S. cardiophyllum*. Expression of 47 kD cosegregated with non acclimated freezing tolerance but not with acclimated freezing tolerance. Our results show that (i) expression of dehydrins is a heritable trait in the *Solanum* diploid population, (ii) there is no direct relationship between relative freezing tolerance and the presence or absence of dehydrin protein following cold acclimation and (iii) based on assays measuring the residual activity of the lactate dehydrogenase (LDH) enzyme following freezing, the cryoprotective influence of 'boiling stable' proteins was species dependent and is related to the freezing tolerance of the species. Supported by USDA/NRI grant 91-3700-6636 to J.P.P. and J.B.B..

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FREEZING TOLERANCE AND ACCLIMATION CAPACITY INCREASED IN CULTIVATED POTATO CROSSED TO WILD POTATO SPECIES

Laurie S. Weiss, John B. Bamberg and Jiwan P. Palta

Dept. of Hort., Univ. of Wisc.-Madison, Madison, WI 53706

Solanum acaule (acl) and *Solanum commersonii* (cmm) represent the extremes of frost tolerance and cold acclimation ability among potato species. We have combined these species with cultivated *S. tuberosum* (tbr) to develop a potato with desired tuber traits and a high degree of frost tolerance. For this purpose diploid cmm was made 4x and crossed with naturally 4x acl. The F1 and F2 appear to exhibit hybrid vigor for vine growth for flowering, but none had frost tolerance greater than the parents. The F1 and F2 were crossed with *S. tuberosum* ssp. *andigena* and *Katahdin* via 2n eggs resulting in 6x 3-way hybrids. These hybrids were evaluated both in the field and

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laboratory for frost tolerance and acclimation ability. Results showed an increase of 1°C of frost tolerance and 2°C increase in cold acclimation capacity in the hybrids as compared to the sensitive tbr parents. Some of the 6x (3-way) hybrids produced significant tubers but yield and earliness needs much improvement. These results demonstrate that it should be possible to move both non acclimated freezing tolerance and cold acclimation ability from wild to cultivated species and offer exciting opportunities to enhance potato production in frost prone areas in the world.

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PB 531

EFFECT OF HIGH TEMPERATURE ON SUCROSE METABOLISM IN SOURCE AND SINK TISSUES OF POTATO

Abbas M. Lafta* and James H. Lorenzen, Department of Crop & Weed Sciences, North Dakota State University, Fargo, ND 58105

Potato plants are sensitive to heat stress, which reduces tuber yield and alters whole plant partitioning. This study was conducted to determine the effect of high temperature on activity of enzymes related to sucrose metabolism in source and sink tissues of potato plants. Potato plants were exposed to two temperature regimes (20 and 28 C) for 3 days. High temperatures resulted in an increase in sucrose synthase and acid and neutral invertase activities in young growing leaves (< 1.5 cm). However, there were no significant changes in these enzyme activities in stems or mature leaves. The results indicate that both sucrose synthase and invertases are involved in sucrose breakdown in young leaves. We will also discuss the role of sucrose phosphate synthase in mature source leaves and how it is affected by temperature and altered partitioning pattern. Activity of sucrose synthase was affected more than ADP-glucose pyrophosphorylase in small growing tubers exposed to high temperatures.

on interpreting the visible spectra in terms of the profile of various types of chlorophyll-protein complexes and relating these to selected aspects of plant pathology and physiology. A computer interfaced imaging spectrometer employing a CCD detector was constructed. It can record the transmitted spectra of up to 31,680 positions for each sample. The instrument was used to study *in vivo* spectra of sugar cane and barley leaves. The light harvesting complex proteins were then 'interpreted' from the spectra and were shown graphically. Excellent results were also obtained when we measured the relative respiration rate of plant roots. A pH sensitive dye Resazurin was used to show the pH changes around a soybean root. The spectral images changing as a function of time were recorded and the relative respiration rate of any position of the root could be determined.

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PB 150

PLANT GROWTH, YIELD, AND WEED CONTROL IN FOUR STRAWBERRY PRODUCTION SYSTEMS

Angela K. Tedesco¹*, Gail R. Nonnecke¹, John J. Obrycki², Nick E. Christians¹, and Mark L. Gleason³, ¹Department of Horticulture, ²Department of Entomology, and ³Department of Plant Pathology, Iowa State University, Ames, IA 50011

Field plots of four production systems of 'Tristar' dayneutral and 'Earliglow' Junebearing strawberry (*Fragaria xananassa* Duch.) were established in 1993. Production systems included conventional practices (CONV), best-management practices including integrated crop management (ICM), organic practices using corn gluten meal, a natural weed control product, (ORG-CGM), and organic practices using a natural turkey manure product (ORG-TM). 'Earliglow' plants grown with ORG-CGM showed the highest number of runners and total vegetative biomass. Plots with CONV and ICM systems using standard herbicide treatments had lower total weed numbers (11 and 18, respectively) than ORG-CGM (63) and ORG-TM (58). 'Tristar' plant growth, yield and berry number were reduced when plants were grown under straw mulch in ORG-CGM and ORG-TM compared to CONV and ICM plots with polyethylene mulch.

911

PB 153

DATE OF RENOVATION AFFECTS YIELD AND COLD HARDINESS OF STRAWBERRY

Bernadine C. Strik*, Neil Bell, and Gina Koskela, Department of Horticulture, Oregon State Univ., ALS 4017, Corvallis, OR 97331

'Redcrest' plants were renovated at 2, 4, 6, 8, or 10 weeks after harvest (WAH) from July 1 to Aug 26, 1992 and July 7 to Sept 1, 1993, plus an unrenovated control. Data on fall yield, maximum cold hardiness, and summer yield and berry weight were collected. For maximum cold hardiness, crowns were subjected to controlled freezing (-8, -11, -14, -17 or -20°C) and then evaluated by oxidative browning. Fall yield in 1993 was greater than in 1992. In 1992, fall yield was comparable for all renovation dates except the latest, 10 WAH. Unrenovated plants tended to have a lower fall yield than renovated plants. In 1993, plants renovated 2, 4, or 6 WAH had higher yields than control or late-renovated plants. Fall yield was not correlated with summer yield in 1993. Plants renovated 4 WAH had a higher summer yield in 1993 than unrenovated plants or those renovated at other times, which all had similar yields. Date of renovation had no effect on berry weight or percent fruit rot. Unrenovated plants and those renovated 2 or 4 WAH were hardier in winter 1992/93 than those renovated later.

912

PB 156

EFFECT OF SOIL STERILIZATION WITH METHYL BROMIDE GAS ON GROWTH AND PRODUCTION OF STRAWBERRY (*Fragaria xananassa*) Duch.

*Ragab, M. I. & Okasha, Kh. A.
Strawberry Improvement Center, Faculty of Agric.
Ain Shams Univ. Cairo Egypt. FAX 5721628

The objective of this work was to study the effect of soil fumigation with methyl bromide and different mulching types on growth and productivity of the strawberry cultivar Chandler. The experiment included 8 treatments which were the combination of 2 soil fumigation treatments x 4 mulching polyethylene types. A split plot design with four replicates was adopted. Soil fumigation treatments (fumigated and non fumigated) were assigned as main plots, whereas the four mulching polyethylene treatments (control, black, white and transparent) were distributed as subplots.

Results indicated that in order to improve the vegetable growth and to increase the high yielding ability of strawberry cv. Chandler, it is recommended to fumigate soil with methyl bromide gas (50 gm/m³) and apply transparent polyethylene soil mulching. Moreover, in strawberry fields where weeds show serious problem, it is better to use the black polyethylene in controlling weeds of both the fumigated and non fumigated soils.

908

PB 533

STUDIES ON NATURE OF SALT TOLERANCE IN OKRA

*Okasha, Kh. A. & Helal, R. M.

Strawberry Improvement Center, Faculty of Agric.
Ain Shams Univ. Cairo, Egypt. FAX 5721626

Salt tolerance of four okra cultivars namely: white velvet; Gold coast; Balady and Eskandarani, were investigated during three different stages of plant development namely: seed germination, seedling and reproductive stages. At both first and second stages of plant development various concentrations of sea water (diluted with tap water) were used for irrigation while at the third stage, various saline water with different electronic conductivities were used for irrigation.

Results of these studies revealed that salinity reduced and delayed seed germination. At this stage, white velvet cv. appeared to be tolerant to salinity. At the seedling stage, salinity generally reduced shoot weight of plant for all tested cultivars and Gold coast was the least affected one. At the reproductive stage, salinity reduced plant growth and total yield/plant but with different degrees depending upon cultivar. In this respect, yield of both Gold coast and Balady was not greatly reduced at the high level of salinity.

The anatomical studies showed that salinity reduced xylem and phloem elements in okra roots depending upon both salinity level and cultivar.

Generally, the obtained results suggest that both Gold coast and Balady okra cultivars can be considered as tolerant genotypes to salinity and recommended for cultivation in both arid and semi-arid lands where salinity is considered a potential problem.

187 POSTER SESSION 27 (Abstr. 910-919) Berries: Culture and Management

IMAGING SPECTROMETER AND ITS APPLICATION TO PLANT STRESS PHYSIOLOGY

NING LI, LARRY S. DALEY, HORT, OSU, CORVALLIS OR 97331

The goal of our project is to develop a non-invasive means to monitor the physiological status of plants. Spectral image acquisition is a powerful analytical approach for determining chemically distinct species in heterogeneous materials. It was found by Callis and Brukner that the combination of a continuously tunable monochromatic light with a thermoelectric-cooled CCD detector offered the best approach. In the *in vivo* spectra of leaf, researches has been focused

913 PB 159
FIELD TRIAL WITH SIX MICROPROPAGATED STRAWBERRY CULTIVARS IN EGYPT

Fouad H. Mohamed* Dept. of Horticulture, College of Agric. Suez Canal University, Ismailia, Egypt.

This experiment was conducted at Ismailia, the largest strawberry fruit production area in Egypt. Runner plants of the second progeny of micropropagated cvs.: Parker, Chandler, Sequoia, Selva, Brighton and Douglas were planted in 1992/1993 to study their growth and fruiting behavior in response to planting density and runner removal. For most cvs. tested, vegetative growth i.e; petiole length and leaf area as well as fruiting i.e; fruit number and yield/plant were increased under 50cm. between plant spacing with runner intact. Sequoia, Chandler and Parker produced the best growth. Fruit size increased with 25cm. spacing and runner removal. The highest early yield was that of Sequoia and Douglas which correlated well with the number of flower trusses produced. Chandler and Selva produced the highest total yield followed by Douglas, Sequoia, Parker and Brighton.

914 PB 182
INDUSTRY/UNIVERSITY COMMITMENTS SPARK RESEARCH AND EXTENSION EFFORTS ON STRAWBERRY IN FLORIDA

Craig K. Chandler*, T. E. Crocker, and E. E. Albrechts Gulf Coast Research & Education Center. University of Florida, 13138 Lewis Gallagher Rd., Dover, FL 33527

During the past 10 years, the Florida strawberry growers, through the Florida Strawberry Growers Association, have made a serious commitment to fund university research on strawberries. They have purchased equipment and donated monies for facilities at Dover. They have also helped support a new faculty position in breeding and genetics. During this same period, the University of Florida has made an equally strong commitment to support strawberry research and extension. These commitments are beginning to pay significant dividends for industry and the University. Cultural and pest management information has been generated that is saving the industry money, and the breeding program is developing new cultivars that will keep the industry competitive in the marketplace. The University has benefitted through the acquisition of new facilities, equipment, and faculty and graduate student support.

915 PB 185
ROOT DISTRIBUTION AND YIELD OF BLUEBERRY

Gail R. Nonnecke*, Department of Horticulture, Iowa State University, Ames, IA 50011
Soil probe samples were taken in the upper 1 m of the soil profile 0.5 and 1 m from the base of five blueberry cultivars (*Vaccinium* spp.) grown in a modified-pH soil. The samples were divided into 12 sections by depth: mulch, 0-5, 5-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, and 90-100 cm. Weights of the organic fraction of blueberry roots were determined by subtracting ashed weights from dry weights for each sample section. Duplicate soil probe samples were taken and soil pH determined at the 12 depths and two distances. Root weights were highest in the upper 20 cm of the soil profile at the 0.5 m distance for all cultivars. Soil pH was 5 and below in the upper 20 cm of the soil. Yield of 11 cultivars was obtained for five years (1988-1992). Total yield averaged over 5 years showed 'Bluejay' as the highest yielding cultivar with 4.43 kg/plant per year. 'Patriot', 'Elliott', and 'Colville' were lower than 'Bluejay' but similar to each other, with yields of 3.42, 3.11, and 3.03 kg/plant per year, respectively.

916 PB 188
WEED THRESHOLDS BY MECHANICAL AND CHEMICAL CONTROLS IN WILD BLUEBERRIES

David E. Yarborough* and Timothy M. Hess University of Maine, Orono MB 04469

Three hundred, 1 m² plots with either 0%, 25%, 50%, 75% or 100% dogbane or bracken fern weed cover were used in the study. The experimental design was completely randomized with two species, three treatments (mow, wipe and untreated), five densities and 10 replications. One half of each plot had weed cover and one half was kept weed free in order to compare the effect of weed density on yield. Plots were treated with either 10% v/v glyphosate in a hand held weed-wiper, mowed with

a string trimmer or left untreated. Wiping was more effective than mowing for reducing weed numbers in the following year. However, wiping reduced yields compared to mowing at higher weed densities. Mowing proved more effective at increasing yields up to 50% weed cover compared to wiping or not treating. Averages from 1991 and 1992 study indicate mowing increases yields compared to wiping up to 50% then tend to decline, but yields remain greater than not treating.

917 PB 191
EFFECT OF DATE OF PRIMOCANE SUPPRESSION ON 'MARION' TRAILING BLACKBERRY: YIELD COMPONENTS

Neil C. Bell*, Bernadine C. Strik, and Lloyd Martin, Department of Horticulture, Oregon State Univ., ALS 4017, Corvallis, OR 97331

Primocanes were cut at ground level at one-month intervals from late April to late July 1991 and 1992. An uncut control was included. Four canes per plant were trained either in August or the following February, the others being removed and measured. Yield data were collected and yield components measured in 1992 and 1993. Cane diameter, main cane length and branch cane length per plant generally declined with later suppression date. Consequently, yield per meter of cane declined with later suppression date. However, cane number and total plant main cane length were greater for all suppression treatments and percent budbreak increased with later suppression date. As a result, April- and May-suppressed plants had increased-yields compared to control plants in both 1992 and 1993, as did June-suppressed plants in 1993. August-trained plants had significantly higher yields than February-trained in both years, primarily because of increased budbreak. The basal section of canes was the most productive, because of increased budbreak and branch cane production.

918 PB 194
EFFECT OF FLORICANE NUMBER AND PRIMOCANE PRUNING ON PRIMOCANE GROWTH IN 'MARION' BLACKBERRY.

Jessica M. Cortell* and Bernadine C. Strik
Department of Horticulture, Oregon State Univ., ALS 4114 Corvallis, OR 97331

Treatments consisting of 0, 4, 8, or 12 floricanes were established in March 1993. An additional treatment was set up with zero floricanes and early primocane pruning. Starting in April and continuing through early November, weekly primocane measurements were taken including: number of nodes, number of primocanes, number of branch canes, length of primocanes, and length of branch canes. Additional plants in each treatment were harvested in August to assess total biomass partitioning. The zero floricanes treatment had a significant increase in the number and length of both primocanes and branches. Primocanes grown without competition from floricanes had a 65 % increase in primocane dry weight. Primocane pruning resulted in significantly shorter internodes, an increase in branch dry weight, and a decrease in total length of the primocanes. The increase in total primocane biomass with removal of the floricanes should contribute to higher yields the following season.

919 PB 197
YIELD ANALYSIS IN EASTERN THORNTLESS BLACKBERRY

Fumiomi Takeda, USDA-AM, Appalachian Fruit Research Station, Kearneysville, WV 25430

Easter thornless blackberries (ETB) are highly productive and commercially grown in several areas of the country. Fruit are acceptable for the fresh market and the processor. Mature plants of ETB cultivars develop 3 or 4 primocanes annually. On these primocanes as many as 15 lateral shoots may develop from axillary buds. In 1992, the effects of lateral shoot numbers on axillary bud break, fruit cluster numbers, berry size, and yield were determined. 'Black Satin' (9-yr-old) vines were dormant pruned to three floricanes with 3, 6, 9, or 12 12-node lateral shoots (108, 216, 324, or 432 axillary buds per plant). In all plants, about 77% of primary axillary buds broke and grew into fruiting laterals. However, percentage bud break of secondary axillary buds was reduced as the lateral shoots per floricanes increased. Pruning severity affected neither berry size (6.4 gm) or SSC (9.5%). Yield per lateral shoot was reduced as lateral shoot number increased. For higher fruit production in ETB, the number of primocanes as well as the lateral shoot numbers per plant must increase.

188 POSTER SESSION 28 (Abstr. 920-935) Vegetables: Postharvest/Food Science

920 PB 461
CONTROLLED ATMOSPHERE AFFECT STORAGE QUALITY OF
ZUCCHINI SQUASH SLICES
Hidemi Izumi* and Alley E. Watada, Horticultural
Crops Quality Laboratory, USDA, ARS, Beltsville,
MD 20705-2350

Physiology and quality of CaCl_2 treated or nontreated 'Elite' zucchini squash slices were monitored during storage in air, low O_2 (0.25, 0.5 and 1%) or high CO_2 (3, 6, and 10%) atmosphere at 10°C. O_2 consumption and CO_2 production were reduced under low O_2 and high CO_2 atmospheres and the reduction was greater with low O_2 . C_2H_4 production was reduced with low O_2 and initially with high CO_2 . After day 2 or 4, C_2H_4 production under high CO_2 increased with the increase being greater at the lower CO_2 level. The amount and severity of injury/decay were less under low O_2 and high CO_2 than air atmosphere. Slices stored under 0.25% O_2 atmosphere had less weight loss and injury/decay and greater shear force and ascorbic acid content than those held in air atmosphere. Microbial count, pH, and color were affected by the low O_2 only on the last day. CaCl_2 had no additive effect.

921 PB 464
EFFECTS OF STORAGE TEMPERATURE AND RELATIVE HUMIDITY ON THE QUALITY OF EIGHT SQUASH VARIETIES
Erik B. G. Feibert* and Clint C Shock, Malheur Experiment Station, 595 Onion Ave., Ontario, OR 97914

Eight winter squash varieties (Table Ace Acorn, Sweet Dumpling, Waltham Butternut, Honey Boat, Sugar Loaf, Spaghetti, Gold Keeper, and Kabocha) were placed in storage 3 weeks after harvested and were stored for 6, 12, or 16 weeks at 5, 10, or 15°C and 50, 60, or 70 percent relative humidity. Before storage Spaghetti squash had low dry weight and low sugars while Kabocha, Sugar Loaf, and Honey Boat had high dry weight and high sugars. Squash of all varieties suffered high spoilage when stored at 5°C. Water losses increased with temperature or with storage at 50 percent relative humidity. Considering both spoilage and water loss, marketable fruit was highest when squash was stored at 10°C or 15°C and 60 or 70 percent relative humidity. Squash sugars were maintained with storage at 5°C and 10%. Squash can be stored for several months at 10°C and 60 to 70 percent relative humidity with little fruit loss or loss of sugar.

922 PB 467
TOLERANCE OF THE GALIA cv. OF MELON (*Cucumis melo* L.) TO IRRADIATION AS A QUARANTINE TREATMENT
Fernando Lalaguna, UTN, Instituto Venezolano de Investigaciones Cientificas, apartado 21827, Caracas 1020-A, Venezuela.

The banning of ethylene dibromide put an end to the exportation of Venezuelan melon to the northamerican market and made it a need testing alternative treatments. Melons were purchased from a grower/exporter and allotted in groups of 24 to the following treatments: control, 0.5, 0.75 and 1 KGy, and dip in water at 53°C for 1 min. alone and plus 0.5 KGy, then they were stored at about 23°C and 70% RH during 2 to 3 weeks in two experiments in one season. All the treatments resulted in comparable ratings for sensory attributes and figures for soluble solids, titratable acidity and ascorbic/dehydroascorbic acid; the melons dipped in hot water showed the lowest decay. With the possible exception of the 1 KGy melons, the treated melons had attributes and lasted as least like the control ones, which indicates that the Galia cv. of melon grown in Venezuela tolerates irradiation with doses useful in quarantine and technological terms.

566

923

PB 470

EFFECT OF HARVEST STAGE ON SOLIDS, ACIDS, FIRMNESS, AND SHELF-LIFE OF TOMATO

J. W. Scott¹ and Elizabeth A. Baldwin², ¹Gulf Coast Research & Education Center, IFAS, Univ. of FL, 5007 60th St. E., Bradenton, FL 34203; ²USDA/ARS Citrus and Subtropical Products Laboratory, Winter Haven, FL 33883

Fruit of 10 tomato (*Lycopersicon esculentum* Mill.) cultigens, including five typical fresh market F_1 's, two $\text{rin}/+F_1$'s, two very firm (ultrafirm) inbreds, and an antisense PG F_1 , were harvested at mature green, breaker, and table ripe stages of development, passed over a grader and taken to a lab (21°C) for analyses of soluble solids, titratable acidity and firmness at the table ripe stage. Shelf life was also measured. Cultigens varied in response to both solids and acids at the three harvest stages, thus there was no clear effect of harvest stage on these variables. The $\text{rin}/+F_1$'s and ultrafirm inbreds were significantly firmer than the other cultigens at the table ripe and breaker stages. Shelf life tended to decrease with maturity at harvest. One $\text{rin}/+F_1$ had the greatest shelf life at all harvest stages. Ultrafirm and antisense PG cultigens had greater shelf life than the other six cultigens at the table ripe stage.

924 PB 473
EFFECT OF PACKAGING ON POSTHARVEST LOSSES OF TOMATOES DURING TRANSPORTATION TO THE MARKET IN ZAMBIA.
Mungule D. Chikoye, Natural Resources Development College, P.O. Box 310099, 15302 Chelston, Lusaka, Zambia.

A two year study was conducted in the high tomato (*Lycopersicon esculentum* Mill.), production area of the country (Central and Lusaka Provinces). Tomatoes for the market are packed in wooden boxes, open metal basins and grass baskets. Approx. 5-10% and 20-30% of the fruits packed in wooden boxes, basins and baskets respectively got damaged in transit from site of production to the market. Damage of fruits in wooden boxes was mainly due to the transportation in vehicles of overripe fruits on bumpy roads. Regarding the other containers damage was caused by stacking the containers, on top of each other as well as having different types of produce on top. Most of the damaged fruits could not be sold as the tomato processing industry is not yet well developed.

925 PB 476
IMPACT BRUISING AND DETERIORATION OF TOMATO FRUIT
Fahad Al-Said and Donald J. Huber*, Horticultural Sciences Dept. POB 110690, Fifield Hall, Univ. of Florida, Gainesville, FL 32611

A general feature of tomato fruit containing genetically reduced levels of polygalacturonase activity is decreased deterioration and cracking, particularly when handled at the ripe and over ripe stages. As fully ripe fruit are metabolically compromised and very prone to mechanical injuries, we investigated the influence of impact bruising on electrolyte leakage, pectin solubility, and depolymerization in ripening tomato fruit.

'Sunny' tomato fruit harvested at the mature-green, turning, and ripe stages of development and subjected to controlled impact injury exhibited elevated ethylene production at all developmental stages. Subsequent analyses were performed on discs prepared from bruised and uninjured pericarp tissue. Discs from bruised tissues exhibited enhanced electrolyte leakage and, in bruised tissues from ripe fruit, enhanced pectin efflux. Levels of soluble pectins derived from ethanol-insoluble powders were unaffected by bruising; however, pectins from bruised ripe fruit exhibited mol wt downshifts relative to those from nonbruised tissues.

926 PB 497
SOFTENING OF GAMMA-IRRADIATED TOMATO FRUITS.
N. El-Assi, D. J. Huber*, and J. K. Brecht, Horticultural Sciences Dept., POB 110690, Fifield Hall, Univ. of Florida, Gainesville, FL 32611-0690

The use of irradiation to increase longevity and quality of horticultural commodities often results in undesirable softening. The biochemical basis of irradiation-induced softening is not well understood. In this study, we investigated the role of the pectic polysaccharides in irradiation-induced textural changes of 'Sunny' tomato fruit. 'Sunny' mature-green and pink fruit subjected to 84 or

240 Krad experienced a dosage-dependent decrease in firmness, an increase in electrolyte leakage, and an increase in chelator-soluble pectins. Additionally, pectins prepared from 240 Krad-irradiated fruit were of markedly lower mol wt compared to those from nonirradiated fruit. Irradiation-induced downshifts in pectin mol wt were also noted for preripe fruit that lack PG activity. Mol wt decreases noted for pectins from 240 Krad-treated fruit exceeded those observed for fully ripe, nonirradiated fruit. The role of other cell wall polymers in irradiation-induced textural changes is currently being addressed.

927

PB 500

EFFECT OF TEMPERATURE AND PERMEABLE COATINGS ON THE STORAGE LIFE OF TOMATOES.

Hugo Ramirez*, Judith Zambrano, and Eusebio Bracho
Posgrado de Horticultura, Escuela de Agronomía, UCLA, Barquisimeto, Venezuela.

They were done studies on the influence of temperature (10, 15 and 24 C) and permeable coatings (Prolong and Primafresh) on the storage life of tomatoes cv 'Large River' and 'Caribbean'. Fruits were obtained from a commercial source in the Clear River area of the Lara State, at the breaker state. Quality measurements included weight loss, color, titratable acidity, pH, total soluble solids and dry matter. Weight loss was highest in the 'Caribbean' cultivar being notorious in the first five days of storage, but it was not observed a meaningful response with respect to permeable coatings. 'Large River' developed color early, though it was affected very little by the temperature of 10 C and Prolong. 'Caribbean' resulted firmer during all the period of storage and the low temperature. Both cultivars showed equal trend with respect to increase total soluble solids. Dry matter showed a similar trend for both cultivars, temperature and permeable coatings.

928

PB 503

ANTIOXIDANT ACTIVITY AND TOTAL PHENOLIC CONTENT IN DIFFERENT GENOTYPES OF POTATO (*SOLANUM TUBEROSUM*)

Mohamed S. Al-Saikhani*, Luke R. Howard and J. Creighton Miller Jr.,
Department of Horticultural Sciences, Texas A&M University, College Station, TX 77845-2133

Two varieties of yellow flesh (Granola and Yukon Gold) and two white flesh (Viking and Russet Norkotah) potatoes were grown near Springlake, Texas in the summer of 1992. Varieties were investigated for their antioxidant activity and total phenolic content. Varieties were significantly different in antioxidant activity and total phenolic content ($P = 0.0001$). Granola had the highest antioxidant activity and Russet Norkotah the highest total phenolic content, while Yukon Gold had the lowest antioxidant activity and total phenolic content. Further study was conducted on tuber parts (distal end, center, and stem end) and among sections within each tuber part. Differences were slight among tuber parts in antioxidant activity, but significant in total phenolic content. Moreover, the differences were slight among the three sections for antioxidant activity and total phenolic content, while the fourth section containing the skin (epidermal tissue) had the highest antioxidant activity and total phenolic content.

929

PB 506

A TECHNIQUE FOR INOCULATING PEPPER FRUITS WITH THE SOFT ROT PATHOGEN, *ERWINIA CAROTOVORA*

John R. Stommel*, Robert W. Goth and Kathleen G. Haynes,
USDA-ARS, Vegetable Laboratory, Beltsville, MD 20705

Bacterial soft rot of bell pepper (*Capsicum annuum* L.), caused by *Erwinia* spp., is a destructive postharvest market disease of this crop. Control is presently limited to chemical treatments. Methods of inoculating pepper fruit were evaluated to develop a reliable technique for soft rot resistance screening. *Erwinia carotovora* subsp. *atroseptica* (Eca) was isolated from partially decayed field grown pepper fruit at Beltsville, MD. Fruit were inoculated with suspensions of Eca via: (a) abrasion with Carborundum, (b) hypodermic puncture, or (c) non-wounded tissue. Inoculated fruit were held under high humidity at 21-23C for two to three days prior to scoring. Degree of soft rot decay was determined via fruit weight loss from two replicates of the experiment over the course of the growing season. Significant differences were not evident among varieties or experiment dates for weight loss due to tissue decay. Hypodermic puncture inoculation was superior to other methods for inducing fruit rot.

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930

PB 509

CHANGES IN CUTICLE CHARACTERISTICS DURING POSTHARVEST HANDLING OF BELL PEPPERS.

R. Báez-Sañudo*, E. Bringas, J. Mercado, M. Báez, J. Siller and A. Gardea.
Centro de Investigación en Alimentación y Desarrollo, A.C., Apdo. Postal 1735, Hermosillo, 83000 Sonora, Mexico. CIAD/DTAOV/RC/010/94.

Dehydration limits bell pepper postharvest life. Research had focused on waxes and individual sealed packages used to prolong shelf-life. Even though, the fruit natural package -the cuticle- is unknown; besides, cuticle functions as a barrier to protect fruits against excessive water loss. The objective of this work was to characterize cuticle changes and their relationships with fruit quality during postharvest handling. Green 'Wonder' bell peppers were stored under marketing conditions (20C; 65-70% RH). Following cuticle isolation determinations included weight changes (CW), permeability and soluble cuticular lipids (SCL). In addition, quality characteristics like firmness, total soluble solids (TSS), titratable acidity (TA) and CO_2 production were monitored every other day. CW and SCL decreased from 2798 to 1398 and 145 to 48 $\mu g/cm^2$, respectively. Permeability was also reduced from 11 to 10 $mg/cm^3 \cdot h$. CO_2 climatic was reached between the 9 and 12th day peaking with 25 $mg/kg \cdot h$. Firmness decreased from 2.1 to 1.1 $Kg \cdot f$, while no noticeable changes were observed on TSS and TA.

931

PB 512

COMPARISON OF THREE CULTIVARS AND TWO HYBRIDS OF ONIONS (TEXAS GRANEX 502 PRR, TEXAS GRANEX 502, HOUSTON, HYBRID GRANEX 33, AND HYBRID GRANEX 429) ON DIFFERENT STORAGE TEMPERATURE.

Juan E. Manzano*, Judith Zambrano and Douglas Delgado.

Universidad Centroccidental Lisandro Alvarado. Barquisimeto.
Posgrado de Horticultura and NURR. Universidad de los Andes.
Trujillo, Venezuela.

Aproximately one Kg of Onions bulbs were put in a plastic net and stored at 5°C, 12°C and room temperature (25-30)°C, with three replications. Analysis of samples were made weekly to detect weight loss during storage for thirteen weeks. Determination of soluble solid content, pH, titratable acidity, reducing sugars were made at weeks two and twelve. Onions stored at room temperature were completely rot, in the week fourteen. Weight loss was lower at 5°C storage. In the cultivar Texas Granex 502. In this cultivar soluble solid and pH increase during storage to low temperature while titratable acidity and reducing sugar decreased. The cultivar Texas Granex 502 was the best.

932

PB 530

PAL INDUCTION AND FRESH-CUT LETTUCE QUALITY

Gloria Lopez-Galvez*, Mikal Saltveit and Marita Cantwell, Dept.
Vegetable Crops, Univ. California, Davis, CA 95616

Phenylalanine ammonia-lyase (PAL) activity in iceberg lettuce (*Lactuca sativa* L.) is increased in response to several kinds of stress, including wounding, exposure to ethylene, and fungal infection. Ethylene-induced PAL activity is correlated with the discoloration and shelf-life of fresh cut lettuce (Couture et al. 1993. HortScience 28:723). The objective of this research was to further characterize the kinetics of wound-induced PAL in fresh cut lettuce. Leaves of different cvs were cut into salad pieces (1.5 x 3 cm), rinsed in chlorinated water, centrifuged manually, and placed into containers at 5 or 15C through which humidified air flowed. Samples were evaluated for overall visual quality and specific types of discoloration. Midrib tissue was also finely cut (1 x 0.5 cm) for enhanced wound-induction of PAL, which was assayed spectrophotometrically. The kinetics of PAL in midrib tissue of fine cut and salad cut lettuce were similar, with maximum activities obtained within 12-16 h at 15C and within 40-60 h at 5C. Maximum PAL levels in the fine cut lettuce were 1.5-2.0 times those observed in the salad cut pieces, and similar to those induced by ethylene. The usefulness of PAL as a predictor of the storage life of fresh cut lettuce depends on simplifying and expediting the PAL assay.

CONTROL OF LIPID OXIDATION IN ASPARAGUS BY VACUUM INFUSION OF ASCORBIC ACID

Durward Smith* and Susan Cuppett, Department of Horticulture and Department of Food Science, University of Nebraska-Lincoln 68583-0919

Both fresh and frozen asparagus rapidly deteriorate in quality due, in part, to the formation of oxidative off-flavors. Anti-oxidants and chelating agents prevent lipid oxidation in vegetables, but increasing the levels of such compounds in whole vegetables is difficult. Vacuum infusion was optimized to saturate asparagus spears with ascorbic acid without damaging tissues. The combination of vacuum infusion of ascorbic acid and thermal blanching effectively prevented the formation of oxidative off-flavors and hexanal during frozen storage. Sensory evaluations correlated with hexanal levels following frozen storage.

934

PB 524

HEAT TREATMENTS EXTEND THE SHELF-LIFE OF FRESH BROCCOLI

Charles F. Forney*, Agriculture and Agri-Food Canada Research Station, Kentville, Nova Scotia, Canada B4N 1J5

Freshly harvested heads of 'Cruiser' or 'Paragon' broccoli (*Brassica oleracea* L. Italica group) were heat treated by holding in water for 1 to 40 min at 42, 45, 48, 50, or 52C. Control heads were held in air at 20C or in 25C water for 40 min. Controls turned yellow in about 3 days at 20C. Treatments at 42C delayed yellowing by 1 or 2 days, while treatments of 45, 48, 50, and 52C prevented yellowing up to 7 days at 20C. Hot water treatments had no effect on water loss of broccoli during storage. Incidence of decay was greater in treated broccoli stored wet compared to the dry control. However, when free water was removed by spinning following treatment, no difference in decay was observed. Treatment of broccoli at 52C for 3 or more min sometimes induced a distinct off-odor. When broccoli was held at 0C for 3 weeks following treatment no differences were observed between control and treated broccoli. However, when broccoli was warmed to 20C following storage at 0C, yellowing of treated broccoli was inhibited. Hot water treatments also delayed senescence at 20C when broccoli was treated following 3 weeks of storage at 0C.

935

PB 521

MAIN SUGAR ANALYSIS OF FRUITS AND VEGETABLES BY HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY

Jorge Siller-Cepeda*, Alfonso Sánchez, Francisco Vázquez, Manuel Báez, René Palacios, Elsa Bringas, Evelia Araiza, and Reginaldo Báez. C.I.A.D., A.C. P.O. Box 1735, Hermosillo, México. 83000 CIAD/DTAOV/RC/94/005.

A rapid and sensitive high performance liquid chromatography method for quantifying simultaneously sucrose, fructose and glucose in fruits and vegetables is reported. Samples were extracted in 95% ethanol, homogenized and treated at 95C for 20 min. The supernatant was stored at -20C overnight and filtered through a G-25 Sephadex column. Aliquots were evaporated, redissolved in water, filtered, and injected. A Sorbex NH₂ column operated at room temperature was used for separations. The sugars were detected at 192 nm. The retention times were 4.8, 5.9 and 10.3 min for fructose, glucose and sucrose, respectively. The method was applied to twenty-one fruit and vegetable species with different maturity stages. In addition, quality characteristics such as firmness, pH, acidity, soluble solids and color were evaluated. Main sugars for the different samples varied among species. In temperate fruits, fructose and glucose were the predominant sugars, while in tropical and subtropical fruits, the main sugar was sucrose. On the sampled vegetables, fructose was the primary sugar, although at very low levels. Quality characteristics coincided with sugar levels found among the different species.

54 ACB ORAL SESSION 1 (Abstr. 940-949) ACB Oral Competition

940

IN VITRO SYSTEMS FOR ENHANCED PRODUCTION OF VALUABLE PHYTOCHEMICALS IN *BEGONIA* SP.

*N.J. George, D.L. Madhavi & M.A.L. Smith. Dept. of Horticulture, University of Illinois, Urbana, Illinois 61801

Many plants can produce bioactive chemicals with medicinal or health benefits, which has stimulated a whole new research effort aimed at extracting & improving natural phytochemicals. *Begonia* is a rich source of biologically-active phytochemicals and an excellent donor for natural anthocyanin pigments. High levels of triterpene compounds and a host of potentially-useful flavonoids have been isolated from *Begonia* sp., which may account for its frequent use as a medicinal plant remedy in a diverse array of cultures worldwide. Deliberate shifting of the physical and chemical microenvironments can have a significant effect on anthocyanins and precursors produced in vitro. This realization offers the potential to thoroughly screen and study valuable phytochemicals from *Begonia*. *Begonia* genotypes from 3 species were screened to identify callus induction techniques. Contamination inherent in the vascular system of one genotype, along with spontaneous organogenesis, were found to be recurrent problems. These were partially alleviated by light and growth regulator treatments. Studies comparing callus and in vitro vegetative tissues as resources for phytochemical extraction are scheduled.

941

AQUARIUM PLANT MICROPROPAGATION: *CRYPTOCORYNE BECKETTII*

Jennifer A. Gargiulo* and Michael E. Kane, Environmental Horticulture Department, University of Florida, Gainesville, FL 32611-0670

The genus *Cryptocoryne* (Araceae) contains some of the most commercially important amphibious species used in the aquarium plant trade. However, seed production is rare and vegetative propagation by rhizome division is extremely slow. Procedures for *in vitro* establishment, axillary shoot proliferation and plantlet acclimatization of *Cryptocoryne Beckettii* Thwaites ex Trimen were determined. Surface sterilized rhizomatous shoot tips were established on a medium consisting of Linsmaier & Skoog mineral salts and organics supplemented with 87.6 mM sucrose, 2.2 µM benzyladenine (BA) and 0.57 µM indole-3-acetic acid (IAA) solidified with 0.8% TC[®] Agar. Effects of medium supplementation with factorial combinations of BA (0 - 25 µM) and IAA (0 - 10 µM) on axillary shoot proliferation from single node explants were determined after 28 days. Maximum axillary shoot proliferation (1-fold increase) occurred on medium supplemented with 25 µM BA and 1.0 µM IAA. Excellent microcutting rooting (100%) was achieved by direct sticking in Vergro Klay Mix A. Greenhouse acclimatization of rooted microcuttings was 100%.

943

INFLUENCES OF NODAL EXPLANT POSITIONS AND MEDIA OVERLAY ON MICROPROPAGATION OF *SHEPARDIA ROTUNDIFOLIA*

Nina D. Pokriots* and Harrison G. Hughes, Department of Horticulture, Colorado State University, Fort Collins, CO 80523

Limited numbers of broad-leaved evergreen species grow well in the cold, dry plains of Colorado. The roundleaf buffaloberry, *Shepherdia rotundifolia* Parry, is a broad-leaved evergreen species that's adaptable to xeriphytic conditions of the Western states. Since little propagation information is available for this species, we studied procedures for clonal propagation with emphasis on tissue culture procedures. In this study, we evaluated the use of liquid media overlays on rapid propagation and the influence of node position on growth. A comparison of media overlay, transfer to fresh media and a control of no transfer (remained in same media) showed limited differences among treatments. Comparison of terminal, middle and basal node sections showed considerable differences. Sections from the middle produced more branches than the terminal and basal sections, though the branches were shorter than the terminal sections.

COLD-STORAGE TREATMENTS AFFECT WATER RELATIONS OF BARE-ROOT TREES

Rick M. Bates* and Alexander X. Niemiera, Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0327.

Shoot and root water potentials were determined for bare-root Norway maple (*Acer platanoides* L.) and Washington hawthorn (*Crataegus phaenopyrum* Med.) seedlings subjected to shoot and root exposure treatments for six cold storage durations. Shoot and root water potentials for all exposure treatments and both species decreased with increased time in storage, and the greatest degree of water stress occurred during the first six weeks of storage. Maple shoot and root water potentials for the exposed shoot treatment were the same as the whole plant covered treatment. In contrast, hawthorn shoot and root water potentials for the exposed shoot treatment were the same as values for the roots exposed treatment. Based on these data, we conclude that desiccation sensitive species such as Washington hawthorn require root and shoot protection to minimize water loss.

SUCTION LYSIMETER TUBES AS A SOLUTION EXTRACTION METHOD FOR SOIL TESTING PEAT-BASED CONTAINER MEDIA

Erica M. Bergman*, Michelle Marshal, Brian Weesies, William R. Argo, and John A. Biernbaum, Michigan State University, Department of Horticulture, East Lansing, MI 48824-1354

A small suction lysimeter tube (SLT) was used to extract media solution samples for twelve pot plant species in peat-based media subirrigated with 50, 100, or 200 mg · liter⁻¹ N and K₂O. Media samples from different pots were also tested using the saturated media extract (SME) procedure. Sample solution pH, EC, NO₃⁻-N and K⁺ were measured with Cardy flat electrode meters. Averaged over crops, solution pH was similar for SLT and SME (after extraction) at each N concentration. The mean (12 crops x 3 reps at each N level) SME and SLT solution EC and K⁺ concentrations were similar for samples collected from the 50 and 100 mg · liter⁻¹ N treatments. NO₃⁻-N values were lower with the SLT than SME method at 50 mg · liter⁻¹ N. SLT levels for EC, NO₃⁻-N, and K⁺ were 27, 39, and 24% higher than SME values for samples collected from the 200 mg · liter⁻¹ N treatments. Sample variation between replicates and between methods for the single pot samples was unacceptable. More testing is needed with SME and SLT samples from the same pot and composite samples from several pots, but SLT sampling is fast, nondestructive, simple, and economical at \$6-7 per tube.

GROWTH AND DEVELOPMENTAL RESPONSES OF POINSETTIA TO CALCIUM NITRATE AND TO 6-BA

Lisa Grishow* and Alejandro Ching, Horticulture Program, NW Missouri State University, Maryville, MO 64468

Some studies have shown that the presence of calcium ions greatly influence the growth of lateral shoots in poinsettia. Rooted cuttings were transplanted in 13.14 cm dia. plastic pots and grown on Metro-mix soil, fertilized with 20-10-S osmocote and watered as needed. Plants were sprayed with 300 & 600 ppm of Ca(NO₃)₂. Others treated with 500 ppm of 6-BA, plus 300 and 600 ppm of Ca(NO₃)₂, and then with 500 ppm of 6-BA. Some plants were left without treatments as check. The average number of lateral bud breaks were highest on plants treated with 6-BA when compared to plants treated only with Ca(NO₃)₂ and the check. The number of lateral bud breaks increased from an average of 11 on the 5th day to 15 on the 30th day whenever 6-BA was applied. The average length of lateral shoots also increased from an average of 10mm the 5th day to over 23mm on the 30th day when 6-BA was applied, but the presence of Ca(NO₃)₂ at 300 ppm lateral shoot growth was greater than at 600 ppm. In general, the average growth rate in height increased in all treatments compared to the check and the presence of Ca(NO₃)₂ further increased the growth in height. Finally, the foliage growth rate (in diameter) was greatly influenced by 6-BA and 600 ppm of Ca(NO₃)₂.

SCREENING MARIGOLD CULTIVARS FOR SUSCEPTIBILITY TO IRON TOXICITY

Nancy K. Todd, Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843

Marigolds are susceptible to a specific nutritional disorder known as "bronze speckling". It has been reported that the disorder is caused by excessive uptake of iron by the plant, which may be due to high levels of Fe in the soil solution or low soil pH. In this experiment, 12 cultivars of marigold (*Tagetes erecta* and *T. patula*) were grown using increasing levels of Fe (0, 5, 15, and 20 mg/l) from Fe DTPA. In the susceptible cultivars, symptoms were observed within 5 days of initial treatment and appeared as a chlorotic mottling. Initial symptoms resembled spider mite damage on older leaves, which gradually became bronze colored in appearance, and finally became necrotic. Downward cupping of leaves was observed in severely affected plants. Severity of necrosis and percent of plant leaves affected (dry weight basis) were evaluated to determine susceptibility of the different cultivars to the disorder. There was a direct correlation between increasing concentration of Fe and occurrence and severity of symptoms. The most susceptible to least susceptible cultivars were determined to be: First Lady, Inca, Discovery, Galore, Pineapple Crush, Perfection Excel, Voyager All Seasons, Nugget, Zenith, Voyager F1 and Diamond Jubilee.

PLANTING DENSITY EFFECTS ON CHARACTERISTICS OF SUN AND SHADE LEAVES OF *EUCALYPTUS NITENS* AND *EUCALYPTUS OVATA*

M. V. Mickelbart*, Department of Plant Science, Lincoln University, New Zealand.

Eucalyptus ovata and *E. nitens* were analyzed for differences in leaf area (LA), leaf dry weight (LDW), leaf water content (LWC), specific leaf area (SLA), chlorophyll (chl), carotenoid (car), and protein (pro) content. A factorial design with 2 species, 3 densities (2340, 6490, and 12990 trees/ha), and 2 leaf exposures (sun and shade) was used. Low light appeared to have a greater affect on changes in leaf composition than planting density. Shade leaves of both species had higher LA, SLA, chl/LDW, car/LDW and chl:car and lower chl/LA car/LA, chl a:b and pro/LDW than sun leaves. Increased density resulted in higher SLA, chl:car ratio, and pro/LDW. Photosynthetic pigment accumulation was greater in shade leaves of *E. ovata*. *E. ovata* therefore, seems to adapt to shade through adjustment of the photosynthetic apparatus, while *E. nitens* adapted to low light primarily through increased SLA. SLA increased with greater planting densities and with decreased light intensity. The increase in SLA in shade leaves was greater in *E. nitens*, accounting for its greater biomass production over all planting densities in a related study.

EFFECT OF IRON AND LIGHT INTENSITY ON GROWTH AND CHLOROPLAST DEVELOPMENT IN C3 AND C4 TURFGRASSES

Damon C. Johnson*, Murray E. Duysen, and Chiwon W. Lee, Department of Crop and Weed Sciences, North Dakota State University, Fargo, ND 58105

The influences of elevated iron concentrations in the nutrient solution and light intensity on growth and the chlorophyll and chloroplast development in Kentucky bluegrass (*Poa pratensis*) 'Touchdown' (C3), creeping bentgrass (*Agrostis palustris*) 'Pennncross' (C3), and buffalograss (*Buchloe dactyloides*) (C4) were investigated. Plants established in peat-lite medium in 11-cm pots were fertilized with a Hoagland solution containing various iron concentrations (0, 0.01, 0.1, 1, 2, 4, 6, 8, 10 mM Fe²⁺) under two different light regimes. Preliminary results indicated that no biomass reduction or toxic symptoms developed in buffalograss when grown with iron levels up to 8 mM under high light conditions. As Fe²⁺ levels were raised, plants became progressively greener with both the chlorophyll-a and chlorophyll-b contents increased. In Kentucky bluegrass, the sizes of chloroplasts and grana stacks in the cell were larger when grown with 2 mM than 0.05 mM Fe²⁺ in the fertilizer solution. The interactions of iron concentration and light intensity on pigmentation and photosynthesis of the three species are currently being determined.

78 ACB POSTER SESSION (Abstr. 950-956A)

ACB Poster Competition

950

PB 443

DOES WOUNDING BEFORE POLLINATION INCREASE SEED PRODUCTION IN SOLANACEOUS PLANTS?

Ellen K. Muchmore, Department of Horticulture and Landscape Architecture, Pullman, WA 99164-6414, (Loverine P. Taylor, Faculty Advisor).

Seed set is affected by many factors. One of the most important is the number of pollen grains that germinate on the stigma. Our research has shown that kaempferol (a plant natural product) is required for pollen germination. Pollen lacking kaempferol does not germinate, but this defect can be reversed by adding powdered kaempferol to the stigma at pollination. Within 24 hours of wounding the corolla or stamens of V26, a *Petunia* inbred, high levels of kaempferol accumulate in the stigma. The requirement for kaempferol in pollen germination, and the high levels that can accumulate in the stigma, suggested that seed set might be enhanced by wounding 24 hours before pollination. We tested this hypothesis in two inbred lines of *Petunia*, a *Petunia* outcross, and another solanaceous plant *Nicotiana glauca* cv. Samsun. The number of seeds per capsule were correlated with the levels of kaempferol in the stigma in wounded and non-wounded flowers.

951

PB 446

RESPONSE OF TOMATOES GROWN IN AN AEROPONIC GROWTH CHAMBER

Michael D. Berg, Department of Horticulture and Landscape Architecture, Washington State University, Pullman, WA 99164-6414 (Preston K. Andrews, Faculty Advisor).

An aeroponic growth chamber is a system for growing plants in air with water and nutrients supplied by intermittent mist. This type of plant growth system is especially useful for experiments where root accessibility is desired. Tomatoes (*Lycopersicon esculentum* L. 'Bonnie Best') were used to test the performance of an aeroponic growth chamber. A nutrient solution mist was applied through spray nozzles suspended below roots of supported seedlings. Mist application was regulated by electric timers, so that mist was applied for 50 sec. every 5 min. during the 16-hr light period, which was supplemented with a high-pressure sodium lamp. Root and stem lengths, leaf number and leaf lengths were measured weekly. Plastochron index (PI) was used to measure rate of leaf initiation. PI increased linearly, indicating uniform initiation of leaf primordia and absence of environmental stresses. Stem and root lengths increased consistently throughout the growing period. Each plant was harvested, separated into leaves, shoots and roots, oven dried, and dry weights measured.

952

PB 449

HYDROGEN CYANAMIDE ENHANCEMENT OF FRUIT SET

Jason C. Powell* and Calvin G. Lyons, Department of Horticultural Sciences, Texas A&M University, College Station, Texas 77843-2133

The state of Texas suffers from a lack of chilling one out of every five years. Reduced yield in temperature fruit crops such as peach (*Prunus persica*) is one detrimental effect associated with inadequate chilling. Field trials with hydrogen cyanamide (Dormex) have demonstrated that a one to two percent solution applied six weeks prior to bloom will substitute for inadequate chilling of up to 150 hours. Field trials with this chemical have provided further insight into some other possible benefits associated with its use such as: increased marketable yields of fruit crops, enhanced fruit size, and an earlier more concentrated harvest. Advantages noted by the use of this product include a possible earlier crop and reduced labor costs.

953

PB 452

COMPATIBILITY OF *AMELANCHIER* SPECIES WITH 'ANJOU' PEAR AND VARIOUS ROOTSTOCKS.

Glenn R. Thayer, Department of Horticulture and Landscape Architecture, Washington State University, Pullman, WA 99164-6414 (Preston K. Andrews, Faculty Advisor).

Dwarfing rootstocks are essential for developing high-density pear orchards with increased precocity. The graft compatibility of *Amelanchier alnifolia*, *A. x grandiflora*, *A. canadensis*, and *A. alnifolia* 'Thiessen' as a rootstock for 'Anjou' pear or as an interstock on 'Bartlett' seedling, 'Old Home x Farmingdale' and *Crataegus* rootstocks are being tested. Twenty rootstock and rootstock/interstock combinations were top grafted 27 Jan. 1994. Ten replicates will be planted in pots for each graft combination in March after callusing. Growth of successful graft combinations will be measured every two weeks. Shoot length and diameter and trunk diameter at a designated reference point will be measured. Leaf color will be evaluated periodically using a Minolta colorimeter. At natural leaf fall, leaf areas will be measured. Graft compatibility will be evaluated. All data will be analyzed by analysis of variance.

955

PB 455

EVALUATION OF WINTER PROTECTION STRATEGIES FOR RED RASPBERRY CANES

Kerrie B. Badertscher* and Harrison G. Hughes, Department of Horticulture, Colorado State University, Fort Collins, CO 80523

Renewed interest in red raspberry production in Colorado has been limited by winter kill of canes. Winter kill in Colorado may be the result of extreme cold temperatures, desiccation, or a combination of the two. We are evaluating winter protection strategies to increase survival and to better understand the winter stress of raspberries. The four (4) cane treatments of red raspberry, *Rubus idaeus* L. cv. Heritage, used were (1) canes bent and wrapped with plastic; (2) canes bent and mulched with hay and soil; (3) canes upright with anti-desiccant spray; (4) a control of canes upright without protection. Moisture content and electrolyte leakage were evaluated at intervals. Relative moisture loss was greatest in the control as compared to the other treatments. The terminal sections of the canes exhibited greater moisture loss as compared to basal sections in the control with a similar trend in the other treatments. Relative survival as indicated by electrolyte leakage was monitored and will be correlated with moisture loss.

956

PB 479

A WILDLIFE HABITAT IN THE SOUTH CAROLINA BOTANICAL GARDEN

Stephen Wilson* (Mary Hague, Advisor), Department of Horticulture, Clemson University, Clemson, SC 29634-4375.

America's rejuvenated interest in environmentalism provides landscape designers an excellent opportunity to integrate natural wildlife habitats within the landscape. Due to urbanization and rapid development, niches for many animals are being destroyed. Too often we rely on our state and national parks to replace what is lost, when we really should begin in our own backyards. In conjunction with the South Carolina Wildlife Federation, the South Carolina State Botanical Garden has initiated a program that will create a Backyard Wildlife Habitat. The purpose of my project is to create a garden with ornamental and native flora to attract local fauna, while educating botanical garden visitors to concepts that they can apply in their own back yards, neighborhoods, schools, and communities.

My presentation will outline the goals, methodology, and results of the project. In addition, I will discuss the concepts that make a site a Backyard Wildlife Habitat.

956A

PB 495

ASSAY FOR DETERMINING GLYPHOSATE TOLERANCE IN *LACTUCA SATIVA*

Jennifer A. Gargiulo*, Russell T. Nagata, and Thomas A. Bewick, Horticultural Sciences Department, University of Florida, Gainesville, FL 32611-0670

An assay was developed to determine the level of resistance to the herbicide glyphosate in transgenic seedlings of lettuce. Results of the seedling assay were correlated to results of a similar assay using callus lines of the identical transgenic plants. Transgenic plants were found to be a 32-fold increase in tolerance to glyphosate when compared to wild type plants. This was similar to the response of these transgenic lines in the callus line assay.

HORTSCIENCE, VOL. 29(5), MAY 1994

18 COLLOQUIUM 1 (Abstr. 990-994)

Recent Advances in Plant Responses to Stress: Bridging the Gap Between Science and Technology

990

RECENT ADVANCES IN PLANT RESPONSE TO MECHANICAL STRESS: THEORY AND APPLICATION

Cary A. Mitchell, Department of Horticulture, Purdue University, West Lafayette, IN 47907-1165

Brief, periodic seismic (shaking) or thigmic (contact rubbing) stress treatments applied to plants growing in a wind-protected environment typically reduce but strengthen vegetative growth and often inhibit reproductive development. Cell division and cell enlargement both are affected. Mechanically dwarfed plants accumulate less leaf area than do undisturbed controls and undergo temporary stomatal aperture reduction following an episode of stress, leading to reduced photosynthetic productivity. Vibration or mild shaking may lead to a slight stimulation of plant growth. Most classes of phytohormones have been implicated to mediate different growth responses to mechanical stress. Physical perturbation turns on the transcription of several genes coding for calmodulin-like proteins. Calcium chelators and calmodulin inhibitors partially negate effects of thigmic stress. Growth rate responses of naive seedlings are immediate and dramatic, suggesting turgor collapse, whereas recoveries are slow and sometimes partial, suggesting reduced wall extensibility in the cell enlargement zone. Mechanical stress may be used for height control of intensively cultivated bench crops or to physically toughen bedding plants prior to outdoor transplant. Physiological hardening remains a question. Mechanical height control avoids use of chemicals but increases risk of wounding and pathogen infection.

991

REGULATION OF PLANT GROWTH RESPONSES TO LOW SOIL WATER POTENTIALS

Robert E. Sharp, Department of Agronomy, 1-87 Agriculture Building, University of Missouri, Columbia, MO 65211

Plant water deficits usually result in severe inhibition of shoot growth, while root growth is less inhibited or even promoted. Recent advances in understanding the physiology of the differential responses of root and shoot growth to low water potentials will be reviewed.

While it might be readily accepted that hormones are important in transducing environmental conditions into growth responses, there is surprisingly little definitive evidence for the role of any hormone in regulating plant growth in soils of low water potential. Using maize seedlings as a model system, the increase in ABA that accompanies plant water deficits has been shown to be required for root growth maintenance, and also to play a role in shoot growth inhibition. The action of ABA in root growth maintenance appears to involve regulation of ethylene synthesis and/or sensitivity, while the mechanism of shoot growth inhibition is not known. Evidence that ABA acts as a root 'signal' controlling shoot growth in drying soil will also be considered.

The importance of osmotic adjustment as a mechanism of growth maintenance at low water potentials has been questioned by suggestions that solute accumulation may be merely a consequence of stress-induced growth inhibition. Recent studies will be discussed which do not support this idea, and suggest that the response may be useful for crop improvement.

992

STRESS TOLERANCE INDUCTION: THE ROLE OF ABA AND HEAT STABLE PROTEINS

L.V. Gusta, Crop Development Centre, Dept. of Crop Science & Plant Pathology, University of Saskatchewan, Saskatoon, Saskatchewan S7N 0W0

Plants acclimate to abiotic stresses, e.g. heat, freezing drought and salinity, in response to environmental cues such as temperature, daylength and water. Plants can respond within minutes to the cue e.g. heat tolerance or within hours or days, e.g. drought and freezing tolerance. Heat shock proteins are measurable within 20 to 30 minutes of a heat stress and the plants acclimate almost immediately. In contrast, proteins related to freezing tolerance are measurable within hours but days are required before a measurable increase in freezing tolerance can be detected. In almost all stresses it appears that the environmental cue effects the water status of the plant which in turn affects the level of endogenous abscisic acid (ABA). ABA has been implicated to ameliorate the stress by inducing genes to

produce stress proteins. There is a certain degree of commodity between stresses in regards to stress proteins, however each stress has their own unique set of stress proteins. For example heat shock proteins did not confer stress tolerance. Proteins involved in water and osmotic stress tolerance share a high degree of commonality. In all stresses a unique class of proteins are synthesized which are classified as heat or boiling stable (do not coagulate at 100°). These proteins are suggested to be involved in the stress response. Many of these heat stable proteins are induced by ABA alone or in combination with jasmonic acid (JA). Analogs of ABA which are either slowly converted to ABA or are degraded slowly or taken up at a faster rate than ABA have been tested for the efficacy in inducing the stress responses. Analogs have also been identified which inhibit the ABA induced response. How these analogs may have practical significance will be discussed.

993

THEORY AND APPLICATION OF GENETIC ENGINEERING FOR STRESS RESISTANCE AND AVOIDANCE

Steven E. Lindow, Department of Environmental Science, Policy and Management, University of California, Berkeley, CA 94720

Genes determining the ability of the bacterium *Pseudomonas syringae* to catalyze ice formation have been cloned and characterized. Ice nucleation active (Ice⁻) strains of this species are common on plants and the supercooling ability of frost sensitive plants is inversely proportional to the logarithm of the population size of Ice⁻ bacteria at temperatures above -5°C. Recombinant Ice⁻ derivatives of *syringae* were produced by site-directed mutagenesis using deletion containing ice genes cloned from this species. The Ice strains colonized potatoes well in field studies, reduced the population size of Ice⁻ bacterial strains by about 50-fold, and reduced the incidence of frost injury an average of 82% in several radiative frosts of temperatures in the range of -3 to -5°C. The ice gene has also been introduced into *Solanum commersonii* to determine its effect on increasing the tolerance of ice formation in this frost tolerant species. Transgenic plants exhibit a much higher threshold ice nucleation temperature than the parental plants.

994

CALCIUM AND ITS ROLE IN PLANT STRESS RESPONSE

Jiwan P. Palta, Department of Horticulture, University of Wisconsin, Madison WI 53706

In recent years evidence has been presented that implicates the role of free (cytosolic) Ca²⁺ as a major metabolic and developmental controller in plants. Calcium concentrations in the cytoplasm are kept very low under normal conditions (10⁻⁶ to 10⁻⁸ M). Small changes in the absolute amount of calcium can create a 10- to 100-fold change in the Ca²⁺ concentration without upsetting the ionic balance of the cell. This feature makes Ca²⁺ an excellent candidate as a second messenger. Thus, a stress induced change in the cytosolic Ca²⁺ could bring a cellular/plant response to stress. This response is thought to be mediated through activation of Ca²⁺ and/or Ca²⁺-calmodulin-dependent protein kinases which in turn mediate the activity of various enzymes via phosphorylation. Recent evidences from the impact of salinity, low temperature, high temperature, and biotic stresses support such a role of calcium. Data on the association between stress-induced injury and perturbation of membrane/cytosolic calcium are available. In addition, evidences for the role of calcium in acclimation to stress have been reported. These studies suggest that manipulation of cellular Ca²⁺ may be one of the approaches we have on hand to bridge the gap between science and technology.

55 COLLOQUIUM 2 (Abstr. 995-999)

Classical and Molecular Approaches to Breeding Horticultural Plants for Disease Resistance

995

GENETIC ENGINEERING FOR CROP VIRUS RESISTANCE
Rebecca Grumet, Horticulture Department, Michigan State University,
East Lansing, MI 48824

One of the first major successes in the genetic engineering of useful traits into plants has been the engineering of virus resistance. The first example of genetically-engineered virus resistance was published in 1986, since then there have been more than 50 reports of genetically engineered plant virus resistance. These examples span a range of virus types, a variety of plant species, and have utilized several different types of genes. A unique feature of the genetically-engineered virus resistance is that the resistance genes came from the virus itself, rather than the host plant. Most examples have utilized coat protein genes, but more recently, replicase-derived genes have proved highly effective. Other strategies include the use of antisense or sense-defective sequences, and satellite or defective interfering RNAs. This talk will provide an overview of the different approaches, possible mechanisms, the crops and viruses to which they have been applied, and progress toward commercial applications.

996

NOVEL APPROACHES TO GENETIC RESISTANCE TO
BACTERIAL PATHOGENS IN FLOWER CROPS

Adelheid R. Kuehnle*, Fure-Chyi Chen and Nellie Sugii, Dept. of
Horticulture, University of Hawaii, 3190 Maile Way, Honolulu, HI
96822 USA

Bacterial diseases continue to plague ornamental crops, Genetic resistance offers one way to manage disease; combined with use of indexed propagules and sanitation, it can be a powerful control. Classical breeding offers some genetic solutions. Introgression, by genetic engineering, of antibacterial genes derived from the *Cecropia* moth is a second breeding approach which appears promising in other horticultural crops. A case study for control of *Xanthomonas*, species of which severely limit geranium, anthurium, and other ornamental production, is given for anthurium. Transgenic anthurium plants expressing or containing antibacterial genes coding for the antibacterial peptides Attacin, P13 and T4 lysozymes, and the modified cecropins Shiva and SB37 were produced and challenged with bacteria. Juvenile and adult plants showed various degrees of tolerance to bacterial blight. The implications of this approach to bacterial disease control in various ornamental cropping systems will be discussed.

997

USE OF MOLECULAR MARKERS IN BREEDING FOR
RESISTANCE TO FUNGAL PATHOGENS.

James D. Kelly, Michigan State University, Crop and Soil Sciences Dept.,
East Lansing MI 48824.

The use of RAPD markers in disease resistance breeding has been successfully demonstrated in horticultural crops. The identification of RAPD markers and their potential role in disease resistance breeding was first demonstrated in tomato; the procedure of bulk segregant analysis for detecting linkages between RAPD markers and genes conditioning resistance to downy mildew was described in lettuce; the use of linked RAPD markers to facilitate the efficient pyramiding of epistatic rust resistance genes to prolong their durability has been illustrated in common bean; the development of allele specific or sequence characterized primers linked to resistance genes has been achieved in pea, bean, tomato, and lettuce. Indirect selection for disease resistance based on molecular markers is not a replacement for classical breeding procedures. Used as tools, markers offer breeders unique opportunities to combine resistance to an array of different pathogens and efficiently pyramid epistatic resistance genes for highly variable fungal pathogens. This would not always be possible in the absence of linked markers.

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CLASSICAL AND MOLECULAR APPROACHES TO BREEDING
FRUIT AND NUT CROPS FOR DISEASE RESISTANCE

Shawn A. Mehlenbacher, Dept. of Horticulture, 4017 ALS Bldg.,
Oregon State University, Corvallis, OR 97331

Disease resistance is an objective of most breeding programs for small fruits, tree fruits, and nuts. Often a moderate level of resistance is adequate, and must be combined with many other desirable horticultural characteristics. Classical methods (a segregating population of the host plant is inoculated with a virulent isolate of the pathogen under environmental conditions appropriate for disease development) have been used with great success and have incorporated both horizontal and vertical resistance. Molecular approaches offer new opportunities and are likely to be appropriate and cost-effective in a few situations. Transformation is not yet routine in fruit and nut crops, and there is a shortage of useful genes. Genetic maps are being constructed using RFLP and RAPD markers in several species, allowing determination of number and location of important genes as well as indirect selection based on linked markers. This presentation will include examples of both classical and molecular approaches as they are used in the genetic improvement of fruit and nut crops with an emphasis on fungal and bacterial diseases.

999

STATISTICAL ANALYSIS OF DISEASE REACTION
DATA USING NONPARAMETRIC METHODS

Kent M. Eskridge,* University of Nebraska,
103 Miller Hall, Lincoln, NE 68583-0712

Breeders need powerful and simply understood statistical methods when analyzing disease reaction data. However, many disease reaction experiments result in data which do not adhere to the classical analysis of variance (ANOVA) assumptions of normality, homogeneity variance and a correctly specified model. Nonparametric statistical methods which require fewer assumptions than classical ANOVA, are applied to data from several disease reaction experiments. It is concluded that nonparametric methods are easily understood, can be productively applied to plant disease experiments and many times result in improved chances for detecting differences between treatments.

120 COLLOQUIUM 3 (Abstr. 1000-1005)

Seedling Morphological and Physiological Adaptation to Abiotic Stress

SEEDLING ROOT AND SHOOT COMPONENTS IN RELATION TO
STAND ESTABLISHMENT

Daniel I. Leskovar* and Peter J. Stoffella, Texas A&M University, Texas
Agricultural Experiment Station, Uvalde, TX 78801 and University of
Florida, AREC, Fort Pierce, FL. 34954.

Initiation, development, and subsequent growth of seedling root and shoot components can have a direct influence on the quality, adaptation, and survival of seedlings, particularly under stress conditions. Taproot, basal, lateral, and adventitious root components (common in dicot plants) each have their own development sequence, growth rate, and may have separate functions for subsequent seedling growth and development. Stresses originating in root components may be expressed in shoots affecting dry matter partitioning between roots and shoots. Partitioning and development of root morphological components and root/shoot growth adaptation to stress environments will be presented for various vegetable species. Implications of root developmental differences in relation to field planting methods will be discussed. Understanding seedling morphology, physiology and assimilate partitioning during early ontogeny would assist directing strategies to improve field establishment and ultimately crop production.

ANOXIA TOLERANCE OF MAIZE SEEDLING ROOTS

B. G. Cobb*, D. L. Andrews, D. M. MacAlpine, J. R. Johnson and M. C. Drew Department of Horticultural Science, Texas A&M University, College Station, TX 77843

We have been examining the response of maize seedling roots to oxygen stress. Previously, we have shown that maize seedlings with primary root lengths of 10cm or greater require a pretreatment with low oxygen (hypoxia) for survival of greater than 12 hours of anoxia. During the pretreatment there is induction of mRNA and increase in enzymatic activity of alcohol dehydrogenase (ADH) and other enzymes that are necessary for alcoholic fermentation. However, we have found that younger seedlings do not need a pretreatment to survive anoxia. They appear to have high levels of ADH and other enzymes that are needed for anaerobic survival at levels equivalent to those that are induced in older seedlings. These results suggest that, at the time of seedling emergence, seedlings may be more adapted to oxygen stress than during later stages of growth.

ADAPTATION OF BEAN SEEDLINGS TO LOW P AVAILABILITY

Jonathan Lynch, Department of Horticulture, The Pennsylvania State University, University Park, PA, 16803

Low P availability is a primary limitation to plant growth on most native soils. Crop genotypes differ substantially in their ability to grow in low P soils. Understanding the physiological basis for such variation would be useful in developing genotypes with superior P efficiency, which would have utility in low-input systems and might permit more efficient fertilizer use in high-input systems. In common bean (*Phasecolus vulgaris*), growth under P stress is reduced because of increased C costs of the root system. Genetic contrasts in P efficiency were not associated with reduced shoot requirement, mycorrhizal associations, chemical interactions with specific soil P pools, or root system size, but were associated with root system architecture. *SimRoot*, an explicit geometric model of bean root growth, confirmed that architectural traits can influence the relationship of root C costs and P acquisition. Root growth responds dynamically to P stress, through changes in the proliferation of lateral roots and the geotropic response of basal roots. Differences in root architecture arising from these growth responses to P stress may account for genetic differences in P efficiency.

PROXIMITY RESPONSES IN PLANT NEIGHBORHOODS MEDIATED BY PHOTOMORPHOGENIC PROCESSES: MECHANISMS AND AGRICULTURAL IMPLICATIONS

Carlos L. Ballaré* and Ana L. Scopel, Dept. de Ecología-IFEVA, Fac. de Agronomía, Univ. de Buenos Aires, Av. San Martín 4453, (1417) Buenos Aires, Argentina.

Our understanding of how plants use light signals to detect and respond to the proximity of neighbors has increased dramatically over the last few years. At the same time, the explosion of biotechnological techniques has opened a variety of opportunities to manipulate the photosensory systems of cultivated plants. Therefore, the idea is beginning to emerge that plastic responses of cultivated plants to population density could be deliberately changed by engineering genotypes with altered photomorphogenic behavior. This talk will provide a review of recent developments in the area of seedling photomorphogenesis, which will be used as a platform to evaluate the realism of current models of plant competition and the agricultural implications of interfering with plant photophysiology.

THE DUAL ROLE OF MANNITOL AS OSMOPROTECTANT AND PHOTOASSIMILATE IN CELERY. D.M.Pharr¹, J.M.H.Stoop¹, M.E.Studer Feusi¹, J.D.Williamson¹, M.O.Massel¹, and M.A.Conkling², Departments of Horticultural Science¹ and Genetics², North Carolina State University, Raleigh

Mannitol, a six carbon sugar alcohol, is widely distributed in nature and is a major photo-translocated photoassimilate in celery. It may also function as a compatible osmolyte providing stress tolerance. Until recently, little was known about the route of mannitol catabolism in sink tissues of higher plants. An enzyme, mannitol dehydrogenase (MDH) that oxidizes mannitol to mannose utilizing NAD as the electron acceptor was discovered (Arch. Biochem. Biophys. 1991, 298:612-619) in "sink" tissues of celery and celeriac plants. The activity of the enzyme is inversely related to tissue mannitol concentration in various parts of celery plants suggesting a role for the enzyme in mannitol catabolism. In osmotressed celery plants, the activity of the enzyme in sink

tissues decreases as mannitol accumulates.

Celery cells growing heterotrophically in suspension culture utilize either sucrose or mannitol as the sole carbon source and grow equally well on either carbohydrate. Mannitol-grown cells contain more MDH activity than sucrose-grown cells, and the activity of the enzyme is correlated with the rate of depletion of mannitol from the culture medium. Cells growing on mannitol contain an internal pool of mannitol but little sugar. Cells growing on sucrose contain internal sugar pools but no mannitol. Mannitol-grown cells are also more salt tolerant than cells grown on sucrose. Our laboratory is involved in studies of the physiological role of the mannitol oxidizing enzyme in regulating mannitol utilization and the role of the enzyme in regulating mannitol pool size during salt and osmotic stress in both celery plants and celery suspension cultures. Current studies on the molecular control of expression of the enzyme will be discussed.

GENETIC AND MORPHOLOGICAL BASES FOR ROOT-BASED SEEDLING STRESS RESISTANCE.

Richard W. Zobel*, USDA-ARES, 1017 Bradfield, Ithaca, NY, 14853

Different root types have different temporal and morphological patterns of development, functionality and adaptation. Root based adaptation to stresses can not be assessed on a root system basis, but must be employed on an individual root type basis. Three different types of root are developed by most seedlings: tap root, basal roots, and lateral roots. These have been demonstrated to have temporally and spatially different developmental and functional patterns. If a stress occurs prior to the onset of an especially sensitive type of root or after that type has shut down functionally, the seedling will demonstrate resistance, when it is not correctly resistant. Timing of screening treatments and scoring of the results is, therefore, extremely critical. Different genotypes within a species demonstrate strong differences in numbers and timing of root initiation and functional maturity for each of the root types. In addition, different types of root demonstrate sensitivity/tolerance to different chemicals, suggesting that functionality and, therefore, resistance/tolerance mechanisms may differ. All root types present on a seedling must be scored for resistance/sensitivity to the stress, even if morphological/physiological symptoms are not readily apparent. The technology (knowledge, software and equipment) necessary to detect tolerance/resistance and to establish genetic selection schemes is available. Root type differences and the potential for genetic selection will be discussed.

189 COLLOQUIUM 4 (Abstr. 10061010) Strategies for Developing Horticulturally Useful Genes

OVERVIEW OF GENE AVAILABILITY, IDENTIFICATION AND REGULATION

Lowell D. Owens, USDA, Agricultural Research Service, Plant Molecular Biology Laboratory, Beltsville, MD 20705

A growing number of horticulturally useful genes have been introduced into plants. Most are designed to impart resistance to pests, but others affect plant morphology, cold or drought tolerance, sucrose transport, starch synthesis, flower color or fruit ripening. Although most of the genes introduced were originally cloned from plants or plant viruses, some were cloned from bacteria or animals. Identification of gene function has generally involved characterization of the gene product prior to cloning the gene. Recent advances in genetic mapping, however, have opened new approaches to cloning genes prior to isolation of the gene product or to an understanding of the biology of the trait conferred. Most candidate genes for introduction need to be modified to achieve the intended purpose. Rational modification is now possible, to a considerable extent, based upon current knowledge of gene structure and regulation. Some guidelines for modification and examples thereof will be examined.

SYSTEMIC ACQUIRED RESISTANCE. Uknes S*, Delaney T. Vernooij B. Friedrich L. Williams S. Chandler D. Weymann K. Kessmann H. Alexander D. Ward E. and Ryals J. Ciba Agricultural Biotechnology, Research Triangle Park, North Carolina 27709

Systemic acquired resistance is a broad spectrum inducible defense response that is associated with the expression of a set of genes (SAR genes). Expression of one of these genes (PR-1a from tobacco) in

transgenic tobacco confers increased tolerance to two oomycete pathogens.

A direct role for salicylic acid (SA) in signaling SAR has been established in tobacco by analysis of transgenic tobacco expressing salicylate hydroxylase (SAH, an enzyme that inactivates SA by conversion to catechol). Tobacco plants that express SAH are blocked in the accumulation of SA and the development of SAR when responding to TMV. Furthermore, both Arabidopsis and tobacco expressing SAH have altered pathogen induced lesion morphology, exemplified by larger spreading lesions.

Putative mutants in SAR gene expression were isolated by screening M2 Arabidopsis plants for altered expression of PR-1 and PR-2 or for sensitivity to pathogen infection following INA treatment. The putative mutants all into two major classes, constitutive (*cim*, constitutive immunity) and non-inducible (*nim*, non-inducible immunity). Several *cim* mutants exhibit a disease lesion phenotype in the absence of pathogen.

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ANTHOCYANIN BIOSYNTHETIC GENES AND THEIR APPLICATION FOR FLOWER COLOR MODIFICATION.

Neal Courtney-Gutterson, DNA Plant Technology Corporation, 6701 San Pablo Avenue, Oakland, CA 94608

The biosynthetic pathway for anthocyanins has been studied using genetic, biochemical and molecular biological tools. In the past decade, the core pathway genes have been cloned; a number of genes which act to modify anthocyanin structure have been cloned more recently. The first results in color modification have been reduced flower color intensity using gene suppression methods. In particular, we have utilized chalcone synthase (CHS) and dihydroflavonol reductase (DFR) genes and sense suppression in our experimental system, *Petunia hybrida*, and in the commercial crops, chrysanthemum (*Dendranthema morifolium*) and rose (*Rosa hybrida*). In *Petunia* a range of new phenotypes was obtained; genetic stability of suppressed phenotypes will be described. In chrysanthemum a white-flowering derivative of a pink-flowering variety will be described. In rose uniform, partial reduction in pigment intensity throughout the flower was observed in over a dozen trans-gene derivatives of a red-flowering variety.

1009

PHENOTYPE MODIFICATION AND DISEASE RESISTANCE VIA REGULATED EXPRESSION OF THE CYTOKININ BIOSYNTHESIS GENE

Ann C. Smigocki*, Plant Molecular Biology Laboratory, ARS/USDA, Beltsville, Md 20705-2350

Cytokinins were first recognized as a class of phytohormones for their ability to promote cytokinesis in cultured plant cells and have since been shown to be involved in a wide range of physiological processes. Most recently, the availability of phytohormone-specifying genes from *Agrobacterium tumefaciens* has allowed for direct in planta manipulation of cytokinin levels. Overexpression of the isopentenyl transferase (*ipt*) gene by constitutive promoters led to enhanced ability of plant cells to undergo shoot organogenesis but the high endogenous cytokinin levels almost completely suppressed root development. Transient overproduction of cytokinins using promoters regulated by environmental and/or developmental factors did not inhibit regeneration of rooted plants. Transgenic plants in which cytokinin levels can be modulated are being used to characterize the participation of cytokinins in fundamental regulatory mechanisms of morphogenesis, delayed senescence, disease resistance and directed nutrient transport. The potential for using reconstructed cytokinin biosynthesis genes in economically important crops is of tremendous agronomic significance.

1010

DELAYED PETAL SENESCENCE IN TRANSGENIC CARNATION USING ANTISENSE ACC OXIDASE.

Keith W. Savin*, Stanley C. Baudinette, Michael W. Graham, Ellen L.-J. White, Michael Z. Michael, Ann Bayly, Chin-Yi Lu, Stephen F. Chandler and Edwina C. Cornish, Calgene Pacific Pty Ltd, 16 Gipps St, Collingwood, Australia, 3066.

Ethylene is essential for the senescence process in many fruit and flowers. In the last two steps in the biosynthesis of ethylene in plants ACC synthase converts S-adenosyl methionine to 1-aminocyclopropane-1-carboxylic acid (ACC). ACC oxidase (ACO) then degrades ACC to ethylene. Inhibitors of ethylene synthesis, such as amino-oxycetic acid, and of the response to ethylene, such as silver thiosulphate, delay or prevent senescence. By expression of an antisense version of ACO RNA, we have generated two varieties of transgenic carnation which produce flowers with an extended vase life. These were produced using the cultivars Red Sim and White Sim. Flowers from these plants produce very little ethylene and normally fail to display the inrolling phenotype typical of senescence in this species. At the time after harvest when inrolling would normally take place (5 days), the antisense ACO flowers produce only barely detectable levels of

endogenous ACO mRNA or ACS (ACC Synthase) mRNA. Exposure to exogenous ethylene (100ppm) induces inrolling and production of ACS and ACO mRNA species. Such carnations will be valuable both as a commercial product and as a tool for further exploring the role of ethylene in carnation flower senescence and leaf wound response.

61 WORKSHOP 1 (Abstr. 1020-1035) Efficient Use of Minerals to Produce High Yield and Optimum Quality Fruit, Vegetables, and Ornamentals

1020

ENVIRONMENTALLY SOUND APPLICATION OF NITROGEN TO OPTIMIZE YIELD AND FRUIT QUALITY IN APPLES.

Esmail Fallahi*, Brenda R. Simons, John K. Fellman and W.M. Colt. Department of Plant, Soil and Entomological Sciences, University of Idaho, 29603 U of I Lane, Parma, ID 83660.

Influence of different quantity and timing of nitrogen application on various physiological aspects of 'Redspur Delicious' apple, including nutritional partitioning, bud initiation, fruit set, yield, fruit quality and nitrate movement in the soil were studied over several growing seasons. Urea at the rates of: 40.2 Kg/ha; 160.8 Kg/ha; 281.3 g/ha; 401.9 Kg/ha; 522.4 K /ha were applied. Each rate of urea was applied: all at full bloom; half at full bloom and half at late spring; or all in fall. In 1993, time of application did not influence yield, fruit weight, color or soluble solids at harvest. Trees that received 401.9 and with 522.4 Kg/ha had higher yield than those with other quantities. Trees with 160.8 and 281.3 Kg/ha had higher yield than trees with 40.2 Kg/ha. Fruit weight in all quantities, except that of 522.4 Kg/ha, were similar. Fruit weight of trees with 522.4 K /ha was reduced. Fruit color was reduced as N quantities increased. Trees with 40.2 Kg/ha N had lower soluble solids than all other quantities. A high level of N increased ethylene and respiration in the fruit. Thus, if the poor color of fruit is due to high nitrogen, a long delay in harvest to improve the color could lead to an over ripe fruit. A preliminary test did not indicate harmful levels of nitrates movement in the soil.

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RECENT ADVANCES IN NATIONWIDE STUDIES OF CRANBERRY NITROGEN NUTRITION

J. R. Davenport* and C. J. DeMoranville, 1 Ocean Spray Drive, Lakeville, MA 02349 and Cranberry Experiment Station, Glen Charlie Road, E. Wareham, MA 02538.

Like many fruit crops, the difference between vegetative and reproductive production in cranberry is strongly influenced by nitrogen supply, as is fruit quality. However, the optimal supply for this crop has not been established. Further, there have been mixed results on whether or not cranberry can metabolize nitrate nitrogen. Within the past 6 years there has been an upsurge in research on cranberry nitrogen nutrition and it has started to provide answers to some of these unknowns. Results from the lab of L. Peterson (U Wi - Madison) have shown that cranberry will take up nitrate nitrogen, however the uptake is minimal unless ammonium nitrogen is present. The work from Peterson's lab has also shown that there is some nitrate reductase activity in cranberry leaves, albeit at very low levels. Work that we have conducted and work by J. Hart's group (OSU) have been the basis for establishing optimal nitrogen rates and timings for cranberry in the different growing areas in North America. Overall, the work from these different groups has shown that, except in extreme situations, 22 - 33 kg N/ha is optimal for cranberry production. However, timing of application varies widely due to weather conditions in the different growing areas.

1022

THE EFFECT OF NITROGEN STATUS ON PRODUCTIVITY AND RECOVERY OF ISOTOPICALLY LABELLED FERTILIZER N BY MATURE ALMOND TREES

Steven A. Weinbaum*, Wesley Asai, David Goldhamer, and Franz J.A. Niederholzer, Department of Pomology, University of California, Davis, CA 95616

A project to study the interrelationships between leaf N conc., relative tree yield (RTY), nitrate leaching and fertilizer N recovery was established in 1990. Collection of pretreatment baseline data was followed by differential rates of N fertilization. Significant differences in leaf N conc. and RTY were obtained in 1992 and 1993, respectively. RTY is defined as tree yield in 1993 expressed as a percentage of pretreatment (1990) yield. ¹⁵N-depleted (NH₄)₂SO₄ was applied postharvest in 1993 to 17 trees differing in RTY and leaf N conc., and recovery of labelled N in the blossoms of these trees (March, 1994) will be discussed.

MANAGING BORON NUTRITION IN DECIDUOUS TREE FRUIT ORCHARDS

Frank J. Peryea, Washington State University, 1100 N. Western Ave., Wenatchee, WA 98801

Boron (B) is an essential micronutrient that is often in inadequate supply in many deciduous tree fruit orchards and must therefore be added as fertilizer. It can also occur at phytotoxic levels because of over-fertilization, use of high-B irrigation water, or naturally in arid soils that are natively high in B. Tree B status is usually characterized by leaf analysis although other diagnostic criteria are being evaluated. Several tests are used to characterize soil B status. Symptoms of B deficiency include blossom blast, poor fruit set and development, shortened internodes, terminal bud death, and shoot dieback. To ameliorate deficiency, B fertilizer may be broadcast or sprayed over the soil surface or sprayed on tree canopies. In some regions, maintenance applications of B fertilizer are made to prevent development of B deficiency. Sodium borates or orthoboric acid are usually used. Fertilizer rates and timing vary with location and farming practices. Symptoms of B excess include reduced or no yield, impaired fruit quality, leaf marginal chlorosis and necrosis, defoliation, and shoot dieback. Boron toxicity is alleviated by leaching B-enriched soil to move B below the root zone.

FERTIGATION IN CITRUS ORCHARDS: A PROMISE OF MORE EFFICIENT AND ENVIRONMENTALLY SOUND FERTILIZATION

Dariusz Swietlik, Texas A&M University-Kingsville, Citrus Center, P.O.Box 1150, Weslaco, Texas 78599

The public is increasingly concerned with the danger of ground water pollution with fertilizer nitrogen and other chemicals. This is because slow water movement in underground aquifers assures the long lasting existence of contaminants. Citrus orchards commonly are heavily fertilized with nitrogen and other mineral nutrients. Fertigation through a low volume irrigation system is a promising new method of efficient use of fertilizer materials because it places mineral nutrients only in the wetted zones where roots are most active. Preliminary studies in Texas indicate that applying nitrogen fertilizers through a low volume irrigation system is a potentially powerful tool in minimizing N fertilizer leaching. When coupled with partial sodding in close tree proximity further reductions in NO₃ leaching may be achieved presumably through uptake into the cover plants and/or indirectly by enhancing biological fixation in the soil. Other potential benefits of frequent N fertigations in citrus orchards will also be discussed based on the experimental data collected in various parts of the world.

THE EFFECT OF METHANOL ON ORANGE FRUIT QUALITY

Heinz K. Wutscher, USDA, ARS, U.S. Horticultural Research Laboratory, 2120 Camden Road, Orlando, FL 32803.

Seven-year-old 'Hamlin' orange on Swingle citrumelo rootstock were sprayed with 30% methanol and 0.05% Silwet surfactant. There were four treatments: one spray application 48 days, two spray applications 48 and 32 days, and three spray applications 48, 32, and 20 days before harvest on December 2, 1993, with five untreated control trees. The treatments were arranged in five replications of randomized, complete blocks throughout the orchard. There were no significant differences in fruit weight, fruit diameter, rind color, rind thickness, juice content, soluble solids, total acids, solids/acids ratio, and juice color of 30 fruit samples collected from each tree. Leaf samples collected at harvest and analyzed for 12 elements showed higher Na and Cl levels in the leaves of the trees treated with methanol once than in those treated three times.

BEST MANAGEMENT PRACTICE FOR NITROGEN FERTILIZATION OF FLORIDA CITRUS IN DEEP SAND

A.K. Alva*, Univ. of Fla., IFAS, Citrus Res. & Edu. Ctr., 700 Expt. Sta. Rd., Lake Alfred, FL 33850

Nitrate pollution of surfacial aquifer is fairly widespread in deep sandy soil areas of Central Florida. Since citrus is a predominant crop in this area, despite lack of conclusive evidence suggesting citrus fertilization

as the source of nitrate pollution, investigations are in progress to develop Best Management Practice (BMP) recommendations for N fertilization of citrus in an effort to improve N use by the trees and to minimize potential nitrate leaching. Our ongoing studies on both young and mature trees have demonstrated that the use of improved fertilizer formulations and programmed application schedules have facilitated to decrease the rate of N application considerably without any adverse impact on tree growth and/or fruit production while minimizing nitrate leaching below the rootzone. Our approach involves developing BMP recommendations on the basis of judicious irrigation management and generating database on N removal by the fruits, annual N contribution to the trees by mineralization of organic N, and N losses including leaching, denitrification, etc.

EFFECT OF NPK FERTILIZATION ON PRODUCTIVITY AND QUALITY OF CITRUS

Ben Ami Bravdo, Hebrew University of Jerusalem, Faculty of Agriculture, P.O. Box 12 Rehovot 76-100 Israel.

Drip fertigation enables control of the root environment in regard to the volume of irrigated soil, the soil matric potential in the immediate vicinity of the roots and the concentration and composition of the minerals. Application of daily NPK fertilization to citrus was found to promote root production with a large surface area and maintenance of controlled NPK concentrations at various stages of growth and development resulted in high productivity due mainly to increased number of fruits produced. Continuous maintenance of appropriate NPK concentrations at the immediate vicinity of the roots during three successive years improved fruit size without apparent reduction in quality. This was attributed mainly to a well balanced crop load and mineral status as expressed in leaf mineral analyses.

COMBINING CONTROLLED RELEASE FERTILIZERS AND DRIP FERTIGATION TO INCREASE EFFICIENCY AND YIELD IN VEGETABLE AND STRAWBERRY PRODUCTION

Wayne L. Schrader, University of California, Cooperative Extension, 5555 Overland Avenue, Building 4, San Diego, California 92123-1291

California vegetable and strawberry growers are expecting legislation which will limit their use of fertilizers and water by crop, acreage, and season. An increasing number of growers are adopting drip irrigation, which affords the opportunity for more precise control of water and nitrogen nutrition. Many growers, however, lack the skills and time necessary to manage and monitor water and fertilizer applications effectively in drip irrigation. Consequently, the need for quick, easy, and reliable methods to manage nitrogen fertility with drip irrigation has increased. Two trials were conducted to evaluate the effectiveness of granular controlled release nitrogen fertilizers in fields where excessive water use had been eliminated by using tensiometers and ET data to manage irrigations. A range of management options for maximizing yield and quality in vegetable and strawberry production with reduced nitrogen and water inputs will be discussed.

PREDICTING IN-SEASON NITROGEN REQUIREMENTS FOR IRRIGATED POTATOES USING NITRATE SAP TESTS

Carl J. Rosen* and Mohamed Errebhi, Department of Soil Science, University of Minnesota, St. Paul, MN 55108

Applying appropriate rates of nitrogen fertilizer during the growing season for potatoes on irrigated sandy soils is an important concern from both a production and environmental standpoint. Although potatoes on sandy soils are responsive to nitrogen fertilizer, high rates of nitrogen applied early in the growing season have been associated with nitrate leaching due to unpredictable rainfall. Use of lower nitrogen rates applied more frequently through the season is one strategy to minimize nitrate losses and improve nitrogen use efficiency. Portable nitrate electrodes were used to measure nitrate concentrations in petiole sap. Diagnostic criteria based on final yield and nitrate sap concentrations at

various growth stages were developed over a three year period. This rapid test can now be used to make an immediate assessment of nitrogen status of the plant and a prediction for whether supplemental nitrogen will be needed. On-farm trials are currently being carried out to demonstrate the use of the sap test as a best management practice.

1030

COMPUTERIZED MULTIFERTILIZER INJECTION SYSTEMS

Athanasios P. Papadopoulos, Agriculture Canada, Research Station, Harrow, Ontario, Canada, NOR 1G0

Horticultural crop management strategists of the past have routinely chosen to remove root-related limitations to productivity by operating at high fertility levels and by excessive irrigation of well-drained soils, without much concern for fertilizer losses to the environment. The relatively low cost of fertilizer as a component of the overall production cost has justified, at least on economic terms, the liberal application of fertilizer on most horticultural crops. However, inefficiencies in fertilizer use can no longer be neglected as society becomes increasingly aware and critical of the valuable energy expended in fertilizer manufacturing and of the damage to the environment from runoff fertilizer. Progress made towards fertilizer use economy will be discussed in relation to the development and use of computer controlled fertilizer injectors which allow the timely application of precise amounts of nutrients according to the changing needs of crops. Seasonal fertigation programs for greenhouse vegetable production in soil and soilless media will be described and corresponding crop performance data will be presented.

1031

EFFECT OF COMMERCIAL HUMIC ACIDS ON MICRONUTRIENT UPTAKE BY VEGETABLES

Hernández, Eovaldo*, Dept. Ciencias Agrarias, Universidad de La Laguna, 38200 Tenerife, Spain

Most of the studies on the effect of humic acids on micronutrient uptake by plants has been carried out in nutrient solutions. Commercial companies have tried, without adequate experimental support, to extend the conclusions of these studies to the production of vegetables in agricultural soils. The effect of humic acids on micronutrient uptake by plants has been attributed to (a) the improved supply of micronutrients to the soil solution caused by a higher rate of release from soil minerals (probably via chelate formation by humic acids) and (b) the improved uptake of micronutrients as consequence of the larger root system promoted by hormonal compounds in the humic acids. In soils with limiting concentration of micronutrients (such as some calcareous soils) and low content of organic matter, chelation of micronutrients by added commercial humic acids might increase their availability to plants. However, in agricultural soils with adequate content of organic matter, no significant effect of commercial humic acids on micronutrient uptake by plants can be detected.

1032

EFFICIENCY OF FERTILIZATION METHODS ON ORNAMENTALS

Timothy K. Broschat, University of Florida, FLREC, 3205 College Ave. Ft. Lauderdale, FL 33314

Spathiphyllum Schott. 'Mauna Loa Supreme' grown for 6 months in a fine sand soil or a 5 pine bark: 4 sedge peat: 1 sand medium (by volume) were fertilized with 7.6g N, 1.4g P, and 4.5g K/3.5-liter container by 4 different methods. The same raw fertilizer prills (21N-3P-12K) were applied weekly as a liquid, monthly as soluble granules, bimonthly as a lightly resin-coated fertilizer (Osmocote), or every 6 months as a heavily resin-coated fertilizer. All leachates were collected and were measured and analyzed weekly for NO_3^- , PO_4^{3-} , and K. *Spathiphyllum* grew best in the sand soil with either of the controlled release formulations, but fertilization method had no effect on growth in the potting medium. Nitrate and K leaching losses from the potting medium were lowest from the controlled release fertilizers and highest from the soluble granules. Liquid fertiliza-

tion resulted in the highest amounts of PO_4^{3-} lost to leaching and controlled release fertilizers the least. In the fine sand soil, NO_3^- leaching was equivalent from all methods. Soluble granules had the highest levels of leached K and PO_4^{3-} and the lightly-coated fertilizer lost the least due to leaching.

1033

REDUCING NITROGEN FERTILIZER APPLICATIONS BY BALANCING THE NITROGEN SULFUR RATIO

Ellen T. Paparozzi*, 377 Plant Sciences, Horticulture Department, University of Nebraska, Lincoln, NE 68583-0724

Fertilizer particularly nitrogen is part of the concern about groundwater contamination. Many floricultural and ornamental plants do not need the high rates of nitrogen that are typically recommended. However, whenever one alters the quantity of a given nutrient the overall nutrient balance, as well as other physiological processes, changes. A brief overview of our research on poinsettias, roses, and chrysanthemums will be presented. Suggested ratios, critical S levels and nutrient problems associated with incorrect balances will be shared. Limitations due to statistical methods and the impact nutrient balance has on certain plant processes such as flowering and coloring and thus, consumer acceptance will be summarized. Future plans in this area may focus on the need for new statistical techniques, nutrient acquisition by roots and consumer perceptions of plant quality.

1034

WASTE WATER IRRIGATION AND MINERAL NUTRIENT STATUS OF FIVE TURFGRASS SPECIES

Wu, L*, L Hong, and Ali M. Harivandi

Department of Environmental Horticultural, University of California, Davis CA 95616.

The effects of high concentrations of Cl^- , K^+ , Mg^{2+} , and Ca^{2+} of the simulated waste water on the growth of turfgrass species and partitioning of these mineral element concentrations in the turfgrass-soil system have been studied. This is a two year project and the waste treatment was started in the first week of October 1993. The waste water contains 17.89 mM of K^+ , 97.5 mM of Ca^{2+} , 78.1 mM of Mg^{2+} , and 389.17 mM of Cl^- . Kentucky bluegrass, perennial ryegrass, tall fescue, bermudagrass, and zoysiagrass have been irrigated with 1/5, 1/10, and 1/20 times concentration of the waste water and mowed weekly at 5 cm high. The preliminary results showed that there was no detectable growth inhibition of turfgrass by the three waste water concentrations. Waste water irrigation significantly increased the uptake of the mineral elements by the turfgrass. Significant reduction of the mineral element concentrations in the leach by the turfgrass system only found under the conditions of low concentration waste irrigation. However, the seasonal growth pattern of the turfgrass species may have significant influence on the partitioning of the element concentrations in the turfgrass-soil system and their concentrations in the leach. This prediction will be detected by the future studies.

1035

CONTAINER ORNAMENTAL PRODUCTION IN AN ARTIFICIAL POTTING MIX

Fred D. Rauch* and Paul K. Murakami, University of Hawaii, 3190 Maile Way, Honolulu, HI 96822

Several trials have been conducted to determine the optimum amendment level for the production of container foliage plants in a 1:1, V:V, peat:perlite potting mix.

Experiments with various controlled-release fertilizers have shown superior growth and quality with resin coated products in an artificial mix. This appears to correspond to the nitrogen source with those containing nitrate and ammonium nitrogen giving better results than those with other nitrogen sources, such as IBDU or urea.

Trials with variable rates of dolomitic lime resulted in better or equal growth and quality of a variety of foliage plants without added lime even at pH levels of 4.0.

These results suggest the recommendations for the production of container plants in mixes without soil need to be reviewed and perhaps revised.

90 WORKSHOP 7 (Abstr. 1037-1041)

Designing the New Land-grant University

1037

DESIGNING THE NEW LAND GRANT UNIVERSITY

D. C. Sanders*, Box 7609, NCSU, Raleigh, NC 27695

Land Grant Universities have undergone tremendous change during the late 1980's and early 1990's. These changes are due to declining resources, changing social needs, the decreasing agricultural components of society, and globalization. Faculty and support positions have been reduced. Research programs have embraced more complex areas of study, leaving adoption of new technologies to extension faculty. The Agricultural Industry has declined in political power as fewer farmers feed more people. All of these conditions lead to many changes in 'THE LAND GRANT UNIVERSITY'. These changes have been the subject of extensive and intensive, previous and continuing study, because of Land Grants' dramatic influence on both American and global society. Representatives of various institutions within and on the periphery of these institutions will provide their vision for the future of this great American institution. The objectives of this workshop are as follows: Articulate and illuminate the major changes that face The Land Grant Universities and provide a glimpse of these institutions in the future. How these institutions will and should deal with and respond to these challenges will be discussed in order to provide a picture of the future that will affect all of our membership at the very core. The impact of these changes on various aspects of these universities will be presented as follows: Research and science, by Representative of National Academy of Sciences; Outreach/extension and regional cooperation, Representative of The New England Consortium; Private foundations, Representative of Kellogg Foundation; The greater university view, Chancellor Emeritus UCD. The observations of these speakers should generate important discussions that will affect our society, its members, and American society, as we come face to face with major changes in the paradigm of the Land Grant University.

COURAGE TO CHANGE: LAND-GRANT COLLEGES OF AGRICULTURE

James J. Zuiches, W. K. Kellogg Foundation, One Michigan Avenue East, Battle Creek, MI 49017-4058

The Board on Agriculture, National Research Council, has established a committee to (a) review the land-grant system of colleges of agriculture, (b) provide an evaluation and assessment of the strengths, opportunities, myths, and stereotypes; and (c) provide a vision for future development and innovation in organizational structures, functions, and processes. The committee has been charged to discuss these topics with stakeholders and constituencies, invite dialogue and contributions to reconceptualizing the system, and create a synthesis and recommendation. At the workshop, I will sketch out the scope of the study, data collection strategies, and initiate the process of dialogue and critique.

1039

THE NEW ENGLAND EXTENSION CONSORTIUM: INTEGRATING RESEARCH AND EXTENSION ACROSS A REGION

John M. Gerber

There is a fundamental need for the land grant system to debate and rediscover its place in society as a learning organization founded upon enhanced internal and external connectivity. Two critical connections are the linkage between research and extension, and cooperation among the states. As with any system in which the component parts are no longer functionally integrated, the land grant system is declining in vitality. Poor cooperation among states and weak linkages between the research and extension functions have reduced the capacity of the system to serve the public good. The New England Extension Consortium was created to enhance public access to the research base of the land grant universities and to increase the efficiency and efficacy of extension programs in the six New England states.

1040

THE LAND GRANT IN TRANSITION – HOW DO WE GET THERE FROM HERE?

Richard M. Foster*, W.K. Kellogg Foundation, One Michigan Avenue East, Battle Creek, MI 49017

Preparing professionals that will be responsive to the food and agricultural issues of the next century presents a dilemma for current food system education programs. What will be the issues? Who will define the issues? Who are our customers? What will be the role of technology? How will we change? How will we know? While we struggle with these questions and others, the answers reside within both the faculty and the constituencies they serve.

1041

DESIGNING THE NEW LAND GRANT UNIVERSITY

James H. Meyer, University of California, Davis, CA 95616

Massive changes occurring in the agricultural industries and expanding societal interests in environmental quality, food safety, competition for natural resources, along with population pressure, are making it 'evident Land Grant colleges of agriculture (LGCA) must reorganize to address a broader interface of both agriculture-related issues and issues relevant to society in general. A reduced focus on agriculture as such must be anticipated, with more emphasis directed toward life sciences, food quality, environmental concerns, and rural-urban interfaces.

Since their establishment in 1862, LGCA have helped U.S. farmers improve production so much that the numbers of people needed in agricultural sector have plummeted, leaving the status and future of these colleges uneasy. Although the original LGCA model was appropriate for its time, the modern environment at scientific and agricultural universities calls for a new model. To achieve renewal, one must change mindset, revise the mission, provide creative, learning leaders and chart the course for evolution of revitalized institutions.

91 WORKSHOP 8 (Abstr. 1042-1045)

Seed Vigor Testing and Utilization

1042

UNDERSTANDING SEED VIGOR

R.L. Sayers*, Asgrow Seed Company, P.O. Box 1235, Twin Falls, ID 83303

Seed vigor is an important consideration today for seed companies as well as seed consumers. Effective use of seed vigor is, however, significantly hampered due to a lack of understanding and education on the subject. Benefits and limitations of seed vigor information will be addressed as they relate to seed companies, regulatory agencies and the seed consumer.

1043

PROBLEMS IN DETERMINING SEED VIGOR IN COMMERCIAL FLOWER LOTS

Robert Conrad*, Ball Seed Co, 622 Town Rd., West Chicago, IL 60185-2698

Repetitive testing of *Impatiens Wallerana* seed by the producer, the flower seed broker, and a commercial greenhouse operator, has led to agreement of final germination percentages but no agreement in vigor rating of these lots.

The results of this testing as well as a discussion of the requirements of commercial flower seed growers will be presented.

A PRACTICAL VIGOR TEST

Aleta L. Meyr, Ransom Seed Lab, Box 300, Carpinteria, CA 93014-0300

Ideally, a vigor test should provide a reasonably accurate forecast of greenhouse or field quality under a wide range of conditions. A vigor test could provide useful data any time during the different stages of development: Before harvest, after harvest, through handling, natural maturation, and decline. Vigor information on a lot of seed is desirable before distribution and conditioning, after conditioning and before planting. Can one vigor test meet all these needs? The most practical seed vigor test should include several different tests which could be combined and indexed. At the Ransom Seed Laboratory we have developed a series of vigor tests which we combine for a vigor index. We perform four tests:

1. Seed weight or seedling length in pelleted seed.
2. Standard % germination as set forth by A.O.S.A.
3. Stand uniformity index at an early count which includes a photograph of one replicate of 25 seedlings.
4. Stress test: % germination at an alternative temperature. (varies from cold tests to heat tests).

No single test is sufficient to communicate seed vigor. If several tests are used to form a vigor index, the actual data for each test should be communicated along with the vigor index, so the user can evaluate the data and utilize the vigor index to its fullest potential.

IMPACT OF SEED VIGOR ON PRODUCTIVITY OF VEGETABLE TRANSPLANT NURSERIES AND MECHANICAL TRANSPLANTING OPERATIONS.

Steven C. Adams, Dole Fresh Vegetables, Inc., P.O. Box 1759, Salinas, CA 93902

Seed vigor has a very subtle effect on the productivity of greenhouses producing vegetable transplants, celery, cauliflower, lettuce, etc. and on today's highly mechanized automatic or semi-automatic transplanting operations. As greenhouse production technology moves from traditional bare root to plug/tray growing systems and as automatic and semi-automatic transplanting operations increase in number, the impact of poor seed vigor is realized.

Measures to mitigate the impact of poor seed vigor in the nursery are: Seed density grading; increased growing cycle in the nursery, hand culling or replanting. Measures to mitigate the impact of poor seed vigor in automatic transplanting operations: increase the number of people following the planter to replace poor vigor plants; use hand fed transplanters.

92 WORKSHOP 9 (Abstr. 1046-1048)

Reduced Use of Fungicide: Pre- and Postharvest

EFFECT OF POSTHARVEST CALCIUM TREATMENT OF APPLES ON POLYGALACTURONASE PRODUCED BY BOTRYTIS CINEREA.

William S. Conway¹, Carl E. Sams³, Rowel B. Tobias¹, Stephane Roy², Alley E. Watada¹, and William P. Wergin², ¹Horticultural Crops Quality Lab, ²Electron Microscope Lab, Beltsville, MD 20705, ³The Univ. of Tennessee, Knoxville, TN 37901.

Decay caused by *Botrytis cinerea* is significantly reduced by increasing the calcium concentration of apple fruit tissue. Electron microscope studies have revealed that cracks in the epicuticular wax may be an important pathway by which calcium penetrates into the fruit and increases the calcium concentration. In fruit inoculated with *B. cinerea*, the decay induced compositional changes in the cell walls of high-calcium fruit were smaller than those observed in the low calcium treatment. The effect of calcium in reducing decay is associated with maintaining cell wall structure by delaying chemical changes in cell wall composition. *B. cinerea* produced five polygalacturonase isozymes *in vitro* but only one *in vivo*. Among the cations studied-m was the most potent inhibitor of polygalacturonase activity *in vitro* studies. Its mode of inhibition appears to involve the alteration of substrate availability for hydrolysis, rather than any direct effect on the active sites of the enzyme.

HEAT AND MODIFIED ATMOSPHERES FOR CONTROL OF POSTHARVEST DECAY

Elizabeth J. Mitcham*, Dept. of Pomology, Univ. of CA, Davis, CA 95616

The produce industry faces a future with reduced access to postharvest fungicides. It has become increasingly important to reduce commodity susceptibility to decay and to develop non chemical methods for decay control. Heat therapy has been demonstrated to be effective for control of numerous decays and is currently practiced for control of anthracnose in mangoes and papayas and for decay control in oranges. The limitations to heat therapy include the often time line between effectiveness and commodity injury and the lack of residual protection. Modified atmosphere has been used effectively for many years by the California strawberry and raspberry industry to allow cross-country shipment of a commodity on which no postharvest fungicides are used. It has been shown that CO₂ concentrations of 15% and higher inhibit the growth of many fungi, including *Botrytis cinerea*, the main cause of strawberry decay. Many commodities cannot tolerate 15% CO₂ for an extended period of time. However, the short term (1 to 3 weeks) tolerance has not been determined. With the loss of postharvest fungicides, we may find that many commodities could benefit from shipment under high CO₂, as have strawberries. The combination of heat therapy and MA will also be discussed.

PSEUDOMONADS AND THE ROLE OF THE ANTIBIOTICS IN THE CONTROL OF GREEN MOLD OF LEMONS. J.S. Parham and

J.L. Smilanick*, USDA-ARS, 2021 South Peach Avenue, Fresno CA 93727

Pseudomonas cepacia LT412W reduced green mold on lemons caused by *Penicillium digitatum*. It produces phenylpyrrole antibiotics which cause inhibition zones in co-culture with the pathogen. Their role in control of the disease was investigated. Mutagenesis of *P. cepacia* (rifampicin resistant) was performed by mating it with *E. coli* S-17 pSUP1021 (kanamycin resistant), which carries the transposon Tn5. Transconjugate selection and screening for absence of inhibition zones identified a stable mutant. Growth of parent and mutant were comparable. When the mutant was co-cultured with the pathogen on lemon albedo agar, no inhibition zone appeared. Similar co-culture on potato dextrose agar with tryptophan (0.05 g/L), a precursor of phenylpyrroles, did not induce inhibition zones. This suggests the mutation is not in tryptophan biosynthesis. Parent and mutant were assayed for phenylpyrroles. They were cultured in nutrient broth, centrifuged, and the cells extracted with acetone. The extract was dried and dissolved in chloroform. It was spotted on nano-SIL C18 TLC plates, run one hour (methanol:acetonitrile:water, 1:1:1), dried, developed with sulfanilic acid, and observed under UV light. The relative mobility of spots from extracts of the parent matched phenylpyrroles, whereas the mutant produced none. Control of decay by the mutant and parent were equal, suggesting no role for phenylpyrroles in suppression of the disease.

148 WORKSHOP 15 (Abstr. 1049-1051)

Growing with the Information Superhighway

COMPUTER RESOURCES AVAILABLE TO HORTICULTURISTS ON INTERNET

L. A. Sistrunk, Department of Horticultural Science, Texas A&M University, College Station, TX 77843-2133

Internet is one of the main components of the information superhighway. By accessing information on networks, we as professionals can add to the information stream and disseminate research data and academic applications in a timely manner. Users worldwide can use this data to add to their ongoing research efforts. Both binary and ASCII files can be transmitted. One of the main obstacles new users must face is locating the proper area of interest. The use of FTP (File Transfer Protocol) allows users to transfer data between their server and other servers on Internet. For help in finding areas of interest there are two common systems being used. One is called Archie and allows the searching of Archie servers with key words. Substring searches can be used if you do not know the

exact name of a resource. Another system is called Gopher and is menu driven. Gopher provides an easier way to search for the information you are looking for, since it allows users to move within modular menu components. LISTSERV, a mail manager system, allows the distribution of information by mailing lists in less time than regular Internet mail programs, further adding to the system efficiency.

1050

COMPUTER AIDED COMMUNICATION FOR HORTICULTURISTS

Tim Rhodus*, Dept. of Horticulture, The Ohio State University, Columbus, OH 43210

Effective communication of horticultural information over long distances requires the ability to present and receive not only text-based information but also images, sounds, and live-action video. Until recently, the Internet enabled users to communicate in each of these four modes, but not simultaneously. However, as a result of the World-Wide Web (WWW) project and the creation of NCSA Mosaic software, Internet users are able to access and deliver practically any form of communication, as long as it can be digitized. Information from around the world on literally thousands of subjects is now available 24 hours a day. Opportunities to communicate with the general public, primary and secondary science students, or practicing horticulturists are no longer limited by publication delays, travel distances, or media limitations.

1051

THE FUTURE INFORMATION SUPERHIGHWAY: HOW WIDE, HOW FAST, HOW ACCESSIBLE?

Timothy J Ng*, University of Maryland, Department of Horticulture, College Park, MD 20742-5611

The National Information Infrastructure (NII) initiative, more commonly known as the "information superhighway," is intended to provide high-speed electronic access to a variety of voice, data, video, and other information services by the year 2000. Initial access to the superhighway will be prioritized for classrooms, libraries, hospitals and clinics. Eventually NII will provide for widespread and open availability of telecommunication and information services to everyone.

Access to NII will be provided via electronic networks, telephone companies and cable operators. Many of the features proposed by NII are currently available in a developmental stage to horticulturists. The accessibility and future evolution of these services--which include those available via Internet (e.g., electronic messaging, data and information services, document delivery) and via telephone and cable companies (e.g. video/audio "on demand," real-time polydirectional compressed video) --will be discussed.

153 WORKSHOP 20 (Abstr. 1052-1054) Where Are We with Plant Biotechnology?

1052

AN ASSESSMENT OF THE APPLICATIONS OF PLANT BIOTECHNOLOGY IN HORTICULTURE

Stephen Garton*, Department of Plant and Soil Science, Alabama A & M University, P. O. Box 1208, Normal, AL 35762

The applications of plant biotechnology in horticulture have been driven by an assortment of biological, economic and sociological factors such as plant health, vigor and uniformity, product quality, cost of propagule, productivity, cost effectiveness, and ethical and environmental concerns. As the potential of biotechnology to impact horticulture continues to grow, it empowers professional horticultural scientists to become knowledgeable about the development of biotechnology and to critically evaluate the possible impacts of future applications in horticultural crops. Current applications and trends in biotechnology will be reviewed and critically assessed.

1053

GENETIC STABILITY OF MICROPROPAGATED PLANTS

Steve McCulloch*, Briggs Nurseries, Inc., Olympia, WA 98501

Briggs Nurseries, Inc. has used micropropagation as method of vegetative propagation for over 20 years. Genetic stability and uniformity of plants that are produced and sold is of the utmost concern to the commercial plant propagator. Genetic stability may be accomplished by ensuring that all shoots formed *in vitro* are of axillary origin and by reducing shoot proliferation rates through the use of lower cytokinin concentrations in the culture medium. Excision and removal of callus during transfer is also necessary to ensure that shoots develop from axillary buds. Various factors that may influence genetic variability and its frequency of *in vitro* derived plants will be discussed with an emphasis on how to reduce them. Three sources of variation with tissue culture derived plants will also be reviewed (Swartz, 1991): a) source plant variability, b) genetic changes *in vitro*, and c) epigenetic or physiological adaptation.

1054

GETTING GENETICALLY ENGINEERED PRODUCTS FROM LABORATORY TO MARKETPLACE

Kanti M. Rawal* and Keith Redenbaugh, Calgene Fresh Inc., 1910 Fifth Street, Davis, CA 95616

Polygalacturonase (PG) is the principal enzyme responsible for the softening of tomato during ripening. Transformation of tomatoes with antisense PG (asPG) results in significant delay in softening so that fruits with color and flavor can be harvested and shipped from the fields to distant markets. Safety evaluations of the genetically engineered tomato varieties were conducted from two perspectives: a) agricultural, and b) human food. Data were submitted to the appropriate agencies to obtain approvals for commercial production and to seek advisory opinion for the safety of food for human consumption. Calgene Fresh Inc. was created to develop human resources, physical facilities and logistic capabilities for year round supply of high quality branded produce. Vertical integration from seed production to direct consumer marketing is necessary to optimize the business endeavor.

190 WORKSHOP 22 (Abstr. 1055-1058) Production and Utilization of Herbs, Spices, and Medicinal Plants: Pacific Northwest and Caribbean

1055

PRODUCTION AND MARKETING OF SPICES, TEA HERBS AND MEDICINAL PLANTS IN THE PACIFIC NORTHWEST

Lon Johnson*, Trout Lake Farm, 40 Warner Rd., Troutlake, WA 98650

Concurrent with the development of the U.S. market for certified organically-grown produce, there has been a growth in the production and marketing of organically-grown botanicals. This activity has been centered in the Pacific Northwest for the past 20 years. The current global market for biologically-grown botanicals has been stimulated by public interest in alternative and traditional plant-based medicines. Trout Lake Farm has organized efforts to stimulate the production and marketing of medicinal plants and spices. The efforts include R&D, growing methodologies, quality assurance, drying, and processing. Research of many ornamentals has revealed potential uses for them other than strictly ornamental. Cultivation is necessary to avoid extirpation of fragile and threatened wild medicinals. The use of organic growing practices is necessary, particularly for specialty crops which have no EPA level inclusions for pesticides. Increasing domestic production of temperate and subtropical herbs and spices helps reduce U.S. imports.

POTENTIAL OF PYRETHRUM PRODUCTION IN PACIFIC NORTHWEST.

B.K. Bhat* and G.Y. Lemma, Botanical Resources, Inc., 5465 Halls Ferry Road, Independence, OR 97351.

Pyrethrins is one of the safest natural insecticides known to man that is least toxic to all warm blooded animals but highly-toxic to a wide range of insect species. The insecticide is extracted from the flowers of pyrethrum (*Chrysanthemum cinerariaefolium* Vis). United States of America consumes almost 85 per cent of the World production of pyrethrins imported from countries like Kenya, Tanzania, Australia and others. The paper discusses the potential of commercial pyrethrum production in the U.S.A., especially in the states of Washington, Oregon, and California.

THE PRODUCTION OF CULINARY HERBS IN THE U.S. VIRGIN ISLANDS: CONSTRAINTS AND SOLUTIONS

Louis E. Petersen*, University of the Virgin Islands Cooperative Extension Service, #2 John Brewers Bay, St. Thomas, U.S. Virgin Islands 00802-9990.

In the U.S. Virgin Islands (USVI), herbs and spices are in great demand, mainly for culinary purposes. These crops include thyme, basil, oregano, parsley, chives, fennel, rosemary and marjoram. Based on estimated total marketable yield of 25 growers in 1993, 10,264 kg of fresh culinary herbs were produced in USVI. During the same period, 21,207 kg of various herbs were imported to the USVI. These data clearly show that local demand for herbs exceeds domestic production. Constraints which limit increased production in USVI include small farm size, limited water resources, absence of mechanization and limited information on crop management practices. Many herb growers use traditional farming practices and for the most part avoid modern approaches to cultivation. Appropriate cultural and management practices (e.g. drip irrigation, mulching, fertilizer, etc.) could potentially boost production and increase overall efficiency despite the reality of small farm acreages. This paper will describe the current status of herb production in the USVI, constraints to production and proposed solutions to improve its economic prospect.

IMPROVING CROP MANAGEMENT SYSTEMS FOR THE PRODUCTION OF CULINARY HERBS IN THE VIRGIN ISLANDS

Manuel C. Palada* and Stafford M.A. Crossman, University of the Virgin Islands Agricultural Experiment Station, RR2, Box 10000, Kingshill, St. Croix, VI 00850.

The Caribbean region is one major source of most herbs and spices consumed in the U.S. Although the U.S. Virgin Islands (USVI) is part of the Caribbean, local production of herbs and spices does not contribute significantly to exports into the U.S. market. Nevertheless, culinary herbs are an important horticultural crop in the USVI and their sale provides income for many small-scale growers. Little research has been done to improve field production in the USVI. Inefficient cultural practices used by growers result in low yields. Lack of information on fertilizer rates, irrigation and pest control methods is a major constraint to high yields. In 1988, the Agricultural Experiment Station initiated a project to improve field production of herbs and spices in the USVI. Use of drip irrigation, mulching and fertilizers has improved yields of basil (*Ocimum basilicum*) and thyme (*Thymus vulgaris*). This paper will discuss crop management studies to improve culinary herb production in the USVI. Increasing production may help reduce U.S. imports of these specialty crops from other Caribbean island nations.

191 WORKSHOP 23 (Abstr. 1059-1061) Methods and Techniques for Testing Chemicals Used for Thinning Fruit Crops

SPRAY APPLICATION TECHNIQUES

C.R. Unrath, Mtn. Hort. Crops. Res. and Ext. Ctr., NCSU 2016 Fanning Bridge Road, Fletcher, NC 28732

The canopy of an apple orchard can be objectively quantified by using tree height and cross row limb spread to calculate the tree row volume (TRV). Use of the appropriate water rate, adjusted for canopy density, is an effective tool for determining full dilute water rate for airblast applications. To save run off most dilute pesticides are applied at 70% of TRV. TRV model use will be discussed and illustrated. Comparison of handgun vs airblast applications showed more deposition and thinner activity w/handgun. Thinners applied at a fixed concentration of a.i. showed decreased activity as volume decreased. Applications at the same a.i./ha, regardless of water volume showed similar activity at and below TRV water and reduced activity at higher than TRV water, indicating activity loss from run off. Added testing showed uniform thinner activity only if water volume was within \pm 20% of tree TRV rate. A fruit dip experiment showed greatly differing natural fruit drop but similar added chemical induced fruit drop between top, lower outside and lower inside of apple trees, a factor which must be adjusted for w/nozzle distribution on large trees.

RESPONSES TO TREATMENTS APPLIED TO LIMBS VS. WHOLE TREES

John A. Barden*, Richard P. Marini, and Ross E. Byers, Department of Horticulture, Virginia Tech, Blacksburg, VA 24061

Researchers often apply treatments to limbs rather than to whole trees. This technique allows the application of large numbers of treatments to a limited number of trees, and also allows adequate replication when a chemical is in very limited supply. The obvious assumption is made that results from limb treatments are representative of those to be expected using whole trees.

Data from several experiments will be discussed that raise serious doubts about the extrapolation of results from limb treatments to whole-trees. The data are from studies with terbacil applied to apple and peach as well as shade treatments to both apple and peach. Girdling studies will also be discussed in which branches isolated by girdling responded very differently than ungirdled branches.

MODE AND SITE OF CHEMICAL THINNER ACTION

Duane W. Greene, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003-0910

Several chemical thinners are available for use on apples: NAA, NAAm, carbaryl ethephon, benzyladenine and a few potential blossom thinners. Blossom thinners are generally applied at 80% bloom and it is thought that they work by damaging the style and/or pollen tube, thus preventing fertilization of the ovules. Postbloom thinners generally act by creating a localized stress at a time when developing fruit are especially vulnerable. The stress conditions are caused by elevated levels of ethylene, lowered levels of auxin or a temporary reduction in carbohydrate available to developing fruit. The most probable mode of action and site of absorption will be discussed for each thinner.

1062

SAMPLING CONSIDERATIONS FOR CHEMICAL THINNING TRIALS
Richard P. Marini, Department of Horticulture, Virginia Tech, Blacksburg,
VA 24061-0327

Counting blossoms before treatment and collecting yield data for whole trees following thinning treatments are expensive practices. Researchers often collect data on sample branches to reduce the time and expense of data collection. How accurate are these techniques? To generate discussion concerning sampling, results will be presented for several experiments where data were collected for whole trees vs. sample branches. Data will also be presented for different ways of assessing fruit size at thinning time. Fruit diameter, fruit weight and fruit volume were recorded for several cultivars over several seasons. I hope to generate discussion about the desirability of these different measures of fruit development.

192 WORKSHOP 24 (Abstr. 1063-1064)

Considerations of Salt Management in Soil and Water for Horticultural Crop Protection

1063

CONSIDERATIONS IN THE MANAGEMENT OF SALINE AND SODIC SOILS FOR THE PRODUCTION OF HORTICULTURAL CROPS.

C.A. Sanchez, Univ. of Arizona, Yuma Agricultural Center, 6425 W. 8th Street, Yuma, AZ 85364.

Approximately 33% of all irrigated lands worldwide are affected by varying degrees of salinity and sodicity. Soils with an electrical conductivity (EC) of, or greater than 4 dS/m are considered saline, but some horticultural crops are negatively impacted if salt concentrations in the rooting zone exceed 2 dS/m. Salinity effects on plant growth are generally considered osmotic in nature, but specific ion toxicities and nutritional imbalances are also known to occur. In addition to direct toxic effects from Na salts, Na can negatively impact soil

structure. Soils with exchangeable sodium percentages (ESPs) or saturated extract sodium absorption ratios (SARs) exceeding 15 are considered sodic. Sodic soils tend to deflocculate, become impermeable to water and air, and have a strong tendency to puddle. Some soils are both saline and sodic. This workshop presentation will summarize various considerations in the management of saline and sodic soils for the production of horticultural crops.

1064

NEW INSIGHTS IN PLANT BREEDING EFFORTS FOR IMPROVED SALT TOLERANCE

Michael C. Shannon, USDA-ARS-PWA, U.S. Salinity Laboratory, 4500 Glenwood Drive, Riverside, CA 92501.

The lack of improvement for salt tolerance has been attributed to insufficient genetic variation, a need for rapid and reliable genetic markers for screening, and the complexities of salinity x environment interactions. Salt tolerance is a quantitative character that has been defined in a multitude of ways subject to changes with plant development and differentiation; thus, assessing salt tolerance among genotypes that differ in growth or development rate is difficult. Salt tolerance also varies based upon concentrations of both major and minor nutrients in the root zone. Plant growth models may provide a method to integrate the complexities of plant responses to salinity stress with the relevant environmental variables that interact with the measurement of tolerance. Mechanistic models have been developed over the last few years that are responsive to nitrogen or drought stress but not to salinity stress. Models responsive to salinity stress would provide insights for breeders and aid in the development of more practical research on the physiological mechanisms of plant salt tolerance.