# ABSTRACTS

## Colloquia
## Workshops
## Contributed Papers (Oral and Poster)

# 90th 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, session numbers (in parentheses) follow the abstract numbers. Example: 840 (PS 12) represents abstract 840 in Poster Session 12.**

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

## 45 COLLOQUIUM 1 (Abstr. 001–006)
## Sustainable Horticulture

001
SARE (SUSTAINABLE AGRICULTURE RESEARCH AND EDUCATION PROGRAM)
George W. Bird, USDA/CSRS, 342 Aerospace Bldg., 14th and Independence Ave., SW, Washington, D.C. 20250

USDA is responsible for SARE (formerly LISA). Sustainable agriculture is defined in the 1990 Farm Bill as an integrated system of plant and animal production practices having site-specific application that will, over the long-term: satisfy human food and fiber needs; enhance environmental quality and the natural resource base upon which the agriculture economy depends; make the most efficient use of non-renewable resources and integrate, where appropriate, natural biological cycles and controls; sustain the economic viability of farm operations; and enhance the quality of life for farmers and society as a whole. Sustainable agriculture is a rapidly emerging concept and social movement. SARE is funded at $6.7 million annually, and managed through regional councils composed of farmers and ranchers, and representatives of non-profit private, agribusiness, government and academic organizations. The councils develop policy, allocate resources and organize oversight protocols. SARE projects place emphasis on whole farm, on-farm resource, economic, environmental, and quality of life issues.

002
LANDSCAPE SUSTAINABILITY: ENVIRONMENTAL, HUMAN AND FINANCIAL FACTORS
Lynn Ellen Doxon*, New Mexico State University, Associate Professor, Cooperative Extension Service, 9301 Indian School Rd., NE, #201, Albuquerque, New Mexico 87112

When determining whether landscaping is sustainable, we should consider environmental, financial and human factors. Environmental factors include: 1) the capacity of the landscape to damage or heal the system within which it is placed, 2) the environmental effects of the cultural techniques and products used in the installation and maintenance of that landscape, and 3) the ability of that landscape to endure without environmentally damaging inputs. Financial factors include: 1) the cost of the landscape compared to the economic return in terms of increased property values, 2) ability to attract and hold industry in a neighborhood, and 3) user fees paid by people attracted to an area by the landscaping. Human factors include: 1) the effects of the landscape on mood, employee retention, health and 2) activity of the individuals who interact with the environment. The ideal landscape would be sustainable in all three of these areas, meaning that there is more benefit than cost environmentally, financially and humanly.

003
WELCOME TO REALITY: AN OVERVIEW OF A LISA PROJECT IN SMALL FRUIT
Barbara L. Goulart, Department of Horticulture, The Pennsylvania State University, University Park, PA 16802

An "in the trenches" researcher/coordinator viewpoint of a northeast regional LISA grant which has been funded from 1989-1993 will be presented. The specifics of the logistics of coordinating a multi-state grant in a fledgling granting program will be emphasized, as well as the



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evolution of the content and focus of the research directions for the grant entitled Evaluation of Alternative Strategies for Small Fruit Production (University of Vermont Agreement No. 92-08-01). This was a project in which five states in the northeastern United States proposed to cooperate on a multi-disciplinary project exploring the biological and economic feasibility of selected production practices for small fruit. These practices were selected because they showed potential for increasing net profit by either reducing purchased inputs or maximizing yield. Information transfer, before, during and after the studies was emphasized, using such diverse means as grower experimental plots, the participation of growers in integrated pest management programs, the development and publication of economic data relevant to the projects, the development of a LISA small fruits newsletter, as well as more traditional means of information dissemination such as grower meetings and trade and scientific publications.

004
THE GREENHOUSE WASTE STREAM
Gale L. Arent, Southwest Regional Exchange, 450 North Ave., Michigan State University, Battle Creek, MI 49017-3397

The 90's are emerging as a decade of the environment. One important dimension is a societal focus on the reduction in the volume of materials that are landfilled. The initial focus of the regulatory community was a reduction in the volume of solid waste generated by large firms. The present focus is community based with local governments developing recycling and other programs to reduce the volume of household waste. These efforts may be followed by greater governmental focus on the waste generated of small to medium sized businesses, including the greenhouse industry. Thus many communities are developing recycling alternatives for several components of the household waste stream that are also present in the greenhouse waste stream. The U.S. Household Waste Stream contains the following volume of various materials: paper 40%, yard waste 18%, metal 9%, food 8%, glass 8%, plastic 7%, and other 10%. During a year-long survey that included pre-disposal visits to greenhouse waste containers in Western Michigan during 1991, the waste stream was identified.

005
AN INTEGRATED DECISION SUPPORT SYSTEM: POTENTIAL FOR HORTICULTURE
John E. Ikerd, Sustainable Agricultural Systems Program, University of Missouri, 200 Mumford Hall, Columbia, MO 65211

Farming operations must be both environmentally sound and economically viable if they are to be sustainable over time. Thus, farmers of the future must be able to balance environmental and economic concerns in making management decisions. An integrated farm decision support system, PLANETOR, has been developed to help farmers balance soil loss, water quality risks, production efficiency, and profitability in the farm planning process.

PLANETOR is a site-specific, field-level, multi-year, computer-based program which allows farmers to evaluate alternative resource management strategies; including cropping sequence, tillage methods, and pest management practices within a whole-farm systems context. The PLANETOR program may be particularly useful for horticultural crop producers who are attempting to use crop rotations and integrated pest management strategies to reduce their reliance on commercial chemical inputs and thus reduce environmental risks and input costs without sacrificing productivity.

006
SUSTAINABLE AGRICULTURE AND THE HORTICULTURAL SCIENCES: LEGISLATIVE ISSUES
Dr. Terry L. Nipp*, Aesop Enterprises, Ltd., 123 Fourth St. SE, Washington, DC 20003.

In this presentation, an overview of the debates regarding sustainable agriculture will be provided, with a review of the interactions among interest groups, the Congress and the U.S. Department of Agriculture regarding the development of programs to promote more "sustainable" agricultural practices. First, the legislative debates over the language and programs included in the 1985 and 1990 Farm Bills will be provided. Second, a summary overview will be provided of the key elements of the sustainable agriculture subtitle of the 1990 Farm Bill (Title 16B). Third, there will be a review of the discussions among representatives of the Land-Grant universities, advocates of sustainable agriculture, commodity group representatives, and USDA officials regarding the implementation of sustainable agriculture mandates in the 1990 Farm Bill. Fourth, current efforts to develop a coalition of support for funding for sustainable agriculture efforts will be discussed. Fifth, the interactions between efforts to promote sustainable agriculture and other environmental efforts will be considered, particularly in regards to the Clean Water Act, the implementation of the Coastal Zone Management Act, and new farm management planning requirements. During the discussion, where appropriate, specific examples will be provided that demonstrate the potential impact of these issues on horticultural sciences and production.

## 47 ORAL SESSION 1 (Abstr. 007–012) Floriculture: Plant Growth Regulators

007
THE INFLUENCE OF WATERING FREQUENCY, BULB SIZE, TEMPERATURE, AND PROMALIN ON FLOWERING OF CYRTANTHUS ELATUS (Jacq.) Traub.
Mark S. Roh*, Roger H. Lawson, Seung Hyun Kim[1], and Ki Byung Lim[2], USDA-ARS, FNCL, Beltsville, MD 20705, [1]Sang Ji Jr. College, Kangwon-Do, Korea, [2]Hungong Seed Co., Seoul, Korea.

**The effects of watering frequency, bulb size, temperature, and Promalin on flowering of Cyrtanthus elatus, were investigated. Bulbs must be 8 cm, in circum., with minimum of 10 leaf bases before the first inflorescence will develop from a swollen leaf base. One inflorescence was initiated for each set of 5 leaf bases. Watering frequencies did not affect flower bud development and abortion. Greater than 73% of plants developing from bulbs larger than 15.3 cm in circum. produced an inflorescence with 4 to 6 flowers when grown at 26/23C (D/N) and sprayed with 3,000 ppm Promalin. Anthesis was accelerated from 64 days to 39 days when temperatures were increased from 16/13 to 26/23C. A second inflorescence was also produced from some Promalin-treated plants grown at 26/23C. Flower bud abortion of inflorescences formed on the outer row of leaf bases appeared to contribute to irregular flowering.**

008
EFFECTS OF UNICONAZOLE ON DRY MATTER DISTRIBUTION, ROOT GROWTH, AND MINERAL NUTRIENT PARTITIONING IN *FORSYTHIA* x *INTERMEDIA* 'SPECTABILIS'
Mack Thetford*, Stuart L. Warren and Frank A. Blazich, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Uniconazole was applied as a foliar spray at 0, 90, 130, 170 or 210 ppm to liners of *Forsythia* x *intermedia* Zab. 'Spectabilis' potted in calcined clay. Plants were harvested 40, 80, 120 and 369 days after treatment (DAT) and various growth data recorded at each sampling. Leaf, stem and root tissue samples were analyzed for N, P and K and expressed in terms of total nutrient content or as a percentage of dry weight (concentration). Uniconazole controlled plant height by suppressing internode length. Leaf and stem growth were suppressed by uniconazole as illustrated by reduced leaf area, leaf dry weight and stem dry weight. Uniconazole also reduced root area, root length and root dry weight. However, root:shoot ratios were not effected by uniconazole, except at 40 DAT. Uniconazole increased foliar N and P concentrations at all harvest dates. Foliar K concentration and content were decreased by uniconazole. Stem N concentration increased with uniconazole application at all harvest dates. Uniconazole decreased stem N, P and K content at all harvest dates. Root N, P and K concentrations were increased by uniconazole at all harvest dates whereas N content was not affected. Uniconazole decreased root P and K content.



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009

AN EVALUATION OF PLANT GROWTH REGULATORS ON GROWTH OF HERBACEOUS PERENNIALS

Paul A. Thomas', and Joyce G. Latimer, Department of Horticulture The University of Georgia, Athens, GA 30602

Growing perennials from plugs in warm greenhouses for early spring sale sometimes yields poor quality plants that possess elongated stems and leaf petioles. The objective of this study was to establish concentration ranges necessary to control the subsequent growth of pre-cooled plugs. Plugs of Iberis, Lobelia, and Aquilegia, and corms of Liatris were established in 10-cm pots. Five plant growth regulators, Bonzi (paclobutrazol), Royal Slo-Gro (maleic hydrazide), Cutless (flurprimidol), Atrimmec (dikegulac sodium) and B-Nine (daminozide), were applied at five rates at 5 wk after transplant. Iberis stem length was reduced linearly with increasing concentration concentration by Royal Slo-Gro (0-1200 ppm), and Atrimmec (0-800 ppm). Atrimmec increased branching of Iberis. Growth of Lobelia treated with Royal Slo-Gro was reduced linearly with increasing concentration of Royal Slo-Gro (0-1200 ppm) or B-Nine (0-10,000 ppm). Bonzi and Cutless reduced Lobelia stem growth linearly with increasing concentration (0-40 ppm). Liatris stem growth was reduced linearly with increasing concentration of Royal Slo-Gro (0 to 1200 ppm). B-Nine, Bonzi and Cutless were also effective on Lobelia; however, a refinement of the concentration ranges used might provide better Lobelia growth management.

010

VOLUME OF SPRAY AND PLANT AGE INFLUENCE EFFICACY OF UNICONAZOLE ON GERANIUMS AND PETUNIAS

Mikael O. Edstrom*, James E. Barrett and Terril A. Nell, Environmental Horticulture Dept., Univ. of Florida, Gainesville, 32611

In a factorial experiment with uniconazole, paclobutrazol, and daminozide applied to petunia 'Midnight Madness' in 10-cm pots using spray volumes of 0, 100, 200, 300, or 400 $ml*m^{-2}$, the chemical*volume interaction was significant. The decrease in plant size with greater volumes was greatest for uniconazole and least for daminozide. In another factorial study, there was an interaction between uniconazole concentration, time of application and spray volume. Volume of spray had more effect on young plants than on older ones, and for the youngest plants the volume response was linear at 20 ppm and quadratic at 40 ppm. On seed geranium 'Bandit Salmon', there was also an interaction between uniconazole concentration, time of application, and volume of spray. The volume effect was greatest on young plants, and response for both 2 and 4 ppm was quadratic. On older plants there was no volume effect at 2 ppm, and response was linear at 4 ppm.

011

HEIGHT CONTROL OF CALADIUMS WITH PACLOBUTRAZOL

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

Experiments were conducted in the Spring of 1991 and 1992 to evaluate the efficacy of paclobutrazol and uniconazole drench and spray applications on the tall-growing *Caladium X hortulanum* (Birdsey) cultivars Aaron, White Christmas, and Carolyn Whorton. Uniconazole was not more active than paclobutrazol on caladiums as has been observed on other species. Single spray applications of paclobutrazol at 200 ppm were less effective than drench applications and did not provide commercially acceptable plant heights. However, sprays at 100 ppm applied twice a week from one to three weeks after planting and directed at the expanding leaves provided adequate height control. Drench applications were applied at week 1, 2, 3 or 4 at concentrations of 0.0, 0.5, 1.0, 2.0 or 4.0 mg ai per pot. Optimum time of application was 3 weeks after planting and commercially acceptable height control was provided by 0.5 and 1.0 mg of paclobutrazol.

012

COMPARISON OF HYDROPHILIC POLYMER AMENDMENT ON MEDIA LEACHATE AND CHRYSANTHEMUM GROWTH

Kenneth C. Sanderson, Department of Horticulture, Auburn University, Auburn University, Alabama 36849

Soil Moist, acrylic polymer, was incorporated into a soil, peat compost, pinebark, and perlite medium at 0, 5, 10, and 20 g per 10 cm (500 ml) pot. One rooted cutting of Dendranthema grandiflora (Ramat) Kitamura was planted into the pot. Prior to planting, each pot received 0.25 mg of ancymidol in a 80 ml drench. Leachate was collected at drenching for foxtail millet bioassay. Chrysanthemum height, dry weight, area, flower number, and date of flowering were recorded at flowering. In a second experiment, Soil Moist, Supersorb C, Agrosoake and Broadleaf brand polymers were evaluated at the manufacturer's recommended rate. Height of millet seedlings grown in ancymidol leachate from polymer-treated media was greater than seedlings grown in ancymidol drench solution. Height of millet seedlings grown with ancymidol leachate from the various polymer media did not differ in height from seedlings which received tap water lechate. Growth parameters were unaffected by polymer rate or brand.

## 48 ORAL SESSION 2 (Abstr. 013–020) Tree Fruit (Temperate): Postharvest Physiology

013

PRESTORAGE HEAT TREATMENTS FOR SCALD CONTROL ON APPLES

E.J. Mitcham* and Y.M. Wu, Dept. of Pomology, Univ. of CA, Davis, CA 95616

To explore alternatives to diphenylamine for control of scald on Granny Smith apples. Freshly harvested, untreated apples were heated before storage. Treatments included hot air at 25C with 10 ppm ethylene for 6 days, 38C hot air for 4 days with and without 10 ppm ethylene, and 5 min dips in hot water at 46C and 50C. Loss of firmness (3 Newtons) immediately after treatment occurred only in apples treated in 38C air for 4 days with and without ethylene. Green color was maintained in all treatments except 38C with ethylene. After heat treatment, fruit were stored at 0.5C in air or CA (1.5% $O_2$, 1% $CO_2$). Fruit were evaluated for color, firmness, soluble solids and titratable acidity at 3 months. Fruit treated at 38C for 4 days with or without ethylene were 7 to 10 Newtons more firm than control fruit and had lower titratable acidity. The remaining treatments were not different from control fruit. All prestorage heat treatments resulted in less scald compared to control fruit. Treatments in air at 38C gave the best scald control with 38C plus ethylene providing slightly better control. The scald which occurred in fruit treated with hot water at 46 or 50C was less than that of control fruit but still significantly high. However, the scald was very faint, and in 50C treated apples may not have been typical scald but a faint bronzing from the high temperature treatment. There was very little scald in any of the CA stored fruit. All prestorage heat treatments resulted in a reduction of bitter pit, especially the two hot water treatments. Control fruit had 31% bitter pit while there was 9% in 46C hot water fruit and 7% in 50C hot water fruit. CA storage reduced bitter pit in control fruit to 17%. Additional fruit will be evaluated after 6 months storage.

014

DARK SKIN DISCOLORATION IN PEACH AND NECTARINE FRUIT IN RESPONSE TO EXOGENOUS CONTAMINANTS

Guiwen W. Cheng* and Carlos H. Crisosto, Department of Pomology, University of California, Kearney Agric. Center, Parlier, CA 93648 USA

Dark skin discoloration development on peach and nectarine cultivars was investigated in response to exogenous pH and metallic ions by using skin discs. The influence of fruit abrasion and washing interaction was studied in a factorial design experiment. Only abraded skin discs developed discoloration after being exposed to high pH and to different metallic ion concentrations. The response of fruit tissue and pure anthocyanins to different pH levels were the same, indicating that anthocyanins was the substrate for the dark color formation. Among the metallic ion contaminants (aluminum, copper, tin, zinc, and sodium) studied, iron was the most effective in causing fruit dark discoloration at the physiological pH. Iron at concentrations equal and/or higher than 10 ppm induced dark discoloration on abraded fruit skin. Dark discoloration development produced by exposing the skin tissue to pH level higher than 6 was reversible while the dark discoloration induced by iron and aluminum ions remained stable. Iron-induced black discoloration was removed by using acidified solution in combination with EDTA.



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015

## PREDICTION OF BITTER PIT ON APPLES USING $Mg^{2+}$ SALT INFILTRATION TO INDUCE BITTER PIT-LIKE SYMPTOMS.

Douglas M. Burmeister* and David R. Dilley, Postharvest Physiology Laboratory, Department of Horticulture, Michigan State University, East Lansing, Michigan 48824

In a 2-year study, induction of bitter pit-like symptoms ($Mg^{2+}$ induced pits) on Northern Spy apples (*Malus domestica* borkh.) by infiltrating $Mg^{2+}$ salt solutions into the fruits was positively correlated with bitter pit that developed during storage. Fruits at harvest were infiltrated with 0.1M $MgCl_2$ in 0.3M sorbitol with 0.1% Tween 20 and placed at 20°C for 10 days (d) after which the number of $Mg^{2+}$ induced pits (MgIP) was determined on individual fruits. A parallel sample of fruits from each orchard was stored at 5°C in air (both years) and at 3°C in air or controlled atmosphere (CA) storage. The prediction was reliable for fruits harvested 20d and 10d before and at optimal maturity for long term storage. The endogenous (native) fruit $Ca^{2+}$ concentration was inversely related to the number of pits induced by $Mg^{2+}$ and to bitter pit development during storage. Pitting induced on the surface of fruits by $Mg^{2+}$ treatment may thus be a reliable indicator of the potential of fruits to develop natural bitter pit.

016

## MODIFIED ATMOSPHERE PACKAGING DETERMINATION OF THE LOW OXYGEN LIMIT OF APPLE FRUIT BY HEADSPACE ETHANOL ACCUMULATION

Christopher D. Gran* and Randolph M. Beaudry, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

'Red Delicious', 'Golden Delicious', 'Marshall McIntosh', and 'Redmax McIntosh' apple (*Malus domestica*, Borkh.) fruit were sealed in low density polyethylene packages and stored at 0 to 25°C (3 to 25°C for 'McIntosh' strains) until steady-state respiration occurred. $O_2$ and $CO_2$ partial pressures for packages were determined, after which headspace EtOH samples were drawn from packages with a range of $O_2$ partial pressures. The lower $O_2$ limit for each variety over the range of temperatures was determined by elevated EtOH levels. As temperatures increased, the minimum $O_2$ partial pressure at which EtOH accumulated increased. Temperature effects varied with cultivars. In the case of 'Golden Delicious' the lower $O_2$ limit (determined by EtOH accumulation) ranged from 0.57 kPa at 0°C to 0.80 kPa at 25°C, while for 'Marshall McIntosh' low $O_2$ limit values ranged from 1.2 kPa at 3°C to 6.4 kPa at 25°C. Macerated tissue EtOH levels mimicked headspace EtOH levels, and headspace accumulation of EtOH with time indicated active fermentation of tissues.

017

## RELATIONSHIPS OF ETHYLENE TO THE DEVELOPMENT OF SUPERFICIAL SCALD ON APPLES

William J. Bramlage* and Zhanyuan Du, University of Massachusetts, Amherst, MA 01003, and Christopher B. Watkins, HRI, Mt. Albert Research Centre, Auckland, New Zealand

When 'Granny Smith' apples were stored at different temperatures, they produced different patterns of ethylene synthesis. Accumulation of α-farnesene and conjugated trienes (CT) in peel of these fruit paralleled ethylene production. Both pre- and postharvest applications of ethephon to 'Cortland' apples increased accumulation of α-farnesene and CT, whereas application of DPA suppressed ethylene production and accumulation of α-farnesene and CT. When both ethephon and DPA were applied, their respective effects were negated. In these experiments, inhibition of ethylene synthesis always reduced scald development after storage, but stimulation of ethylene did not always increase scald development. Ethylene had two effects: an immediate stimulation of α-farnesene and CT accumulation which increased scald susceptibility, and also a slowly developing alteration of CT metabolism, which reduced scald susceptibility. The effect of high ethylene on scald development depended on the balance between these responses.

018

## CHANGES IN NON-ETHYLENE VOLATILE SYNTHESIS DURING PHYSIOLOGICAL DEVELOPMENT OF 'BISBEE DELICIOUS' APPLES

J.P. Mattheis*, J.K. Fellman, P.M. Chen, M.E Patterson, USDA,ARS, Tree Fruit Res. Lab., 1104 N. Western Ave., Wenatchee, WA 98801, DPSE,Univ. Idaho, Moscow, ID 83843, Mid-Columbia Exp. Sta., Oregon State Univ., Hood River, OR 97331, DHLA, Washington State Univ., Pullman, WA 99164.

'Bisbee Delicious' apples were harvested in two orchards over a two-month period prior to and after commercial harvest during three consecutive production seasons. Changes in the predominant non-ethylene volatile compounds (NEVs) were characterized using dynamic headspace sampling with subsequent analysis by GC-MS. Alcohols and aldehydes were the predominant qualitative and quantitative NEVs in preclimacteric apples although other compounds were consistently present. The concentration of total NEVs declined to a minimum prior to the onset of the climacteric rise in ethylene synthesis. The increase in total NEVs after this minimum was attributable largely to increased production of esters. Initial detection of major esters associated with ripening 'Bisbee Delicious' apples occurred prior to onset of the climacteric, however, amounts approached the limits of detection. The large increase in ester synthesis during ripening was coincident with the onset of the climacteric. Quantitative differences between orchards and production seasons were observed. Differences between harvest dates and orchards carried through storage in air at 0 C or 1% $O_2$/2% $CO_2$ CA storage at 0 C.

019

## PHYSICAL AND CHEMICAL CHARACTERISTICS OF APPLES FROM SEVERAL COUNTRIES.

Anton J. Bongers*, Lawrence A. Risse and Vincent G. Bus, USDA-ARS, European Marketing Research Center, Marconistraat 38, 3029 AK Rotterdam, the Netherlands.

Comparisons were made of the major physical and chemical characteristics of seven cultivars of apples (Malus domestica Borkh.) produced and imported into Western Europe from 13 origins. During the 1990-91 (September-August) marketing season, 'Delicious', 'Golden Delicious' and 'Granny Smith' apples from the U.S. were included in the study. Physical characteristics evaluated were length-to-diameter ratio, shape, external defects, internal defects, watercore, bruises, firmness, blush surface and color. Chemical characteristics evaluated were starch, juice content, soluble solids, acids and ascorbic acid. Statistically significant differences in some of these quality characteristics were found between the different origins. U.S. produced apples, particularly 'Delicious', had some superior quality characteristics compared to fruit from other origins.

020

## SOURCES OF VARIATION IN FRUIT QUALITY OF 'BRAEBURN' APPLE AT HARVEST AND AFTER STORAGE.

D. Stuart Tustin*, Christopher B. Watkins, Wendy M. Cashmore, and Paul L. Brookfield, Horticulture and Food Research Institute of New Zealand, Private Bag 1401, Havelock North New Zealand.

Export-packed fruit of 'Braeburn' apple were collected on three dates corresponding to the early, mid and late periods of commercial harvest. Fruit were segregated into categories determined by background color, combined with percent fruit surface area with red blush of <40%, 40-70% and >70%. A separate category comprised fruit which showed marginal sunburn discolouration. Fruit were assessed at harvest and after 16 weeks air storage at 0°C. Quality and maturity indices which were affected by harvest date included starch pattern index, flesh firmness and soluble solids concentration (SSC). However differences due to harvest date were not evident after storage. Fruit with more yellow background color or marginal sunburn were distinguished by advanced starch hydrolysis, higher internal ethylene concentration and higher SSC at harvest. After storage these fruit had yellowest background color, softer flesh and highest SSC. Fruit with green-yellow background color and >70% blush showed similar but less pronounced trends. Organoleptic assessment after storage showed a higher frequency of inferior texture and juiciness associated with categories of fruit with indices indicating advanced maturity at harvest and following storage.

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# 49 ORAL SESSION 3 (Abstr. 021–027) Cross-commodity: Biotechnology/Tissue Culture

021

IN VITRO MAINTENANCE OF CHIMERAL PEAR

Abdelrahman S. Al-Wasel* and Robert M. Skirvin, University of Illinois, Department of Horticulture, Urbana, IL 61801

Variegated 'Louise Bonne' (LB) pear shoots propagated in vitro tend to segregate spontaneously into green, albino, pale, or rearranged chimeral types. This instability makes it difficult to maintain LB in its original chimeral form. This study was initiated to investigate the role of growth regulator combinations on chimeral stability and to find a combination that could be used to maintain the chimera through repeated subcultures. Shoots were most stable (70 to 90% remained chimeral) on LePoivre (LP) medium supplemented with less than 8 $\mu$M BA. Shoots grown at concentrations greater than 8 $\mu$M were less stable (37 to 58%). Cultures grown with thidiazuron (TDZ) were very unstable (7 to 46%). NAA at the highest concentrations (5 and 10 $\mu$M) decreased chimeral stablity both alone (40 and 8%, respectively) and in combination with TDZ (7 to 16%). The implications of growth regulator combinations on long-term chimeral maintenance in vitro will be discussed.

022

IN VITRO SHOOT PROLIFERATION OF MUSSAENDA 'DOÑA LUZ'

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

Mussaenda, a floriferous woody ornamental from the Philippines, is being investigated as a novel flowering potted crop in the United States. One drawback to the development of Mussaenda has been the poor asexual propagation during the winter months. Micropropagation offers an alternative to asexual propagation and allows a constant supply of clonal cuttings throughout the year.

Cultures of the cultivar, 'Doña Luz', were established in vitro on a Murashige and Skoog salts media with 100mg myo-inositol/L, 0.4mg thiamine HCl/L, 30g sucrose/L, and 7g agar/L at pH 5.8. Individual aseptic shoot tips were transferred to proliferation media to determine the optimum micropropagation medium. The proliferation media had the same basic medium components as previously described with six levels of 6-benzylaminopurine (BAP), two levels of napthelene acetic acid (NAA), and two levels of adenine sulphate. The levels of BAP were 0, 2.5, 5.0, 10.0, 20.0, and 40.0 $\mu$M. NAA was used at 0 and 1.0 $\mu$M while the levels of adenine sulphate were 0 and 217 $\mu$M.

Excellent shoot proliferation was noticed with preliminary experiments using the medium containing 10 $\mu$M BAP and 217 $\mu$M adenine sulphate. In addition, root production was observed in preliminary studies with a basal MS medium. Further results from the factorial experiments described will be discussed.

023

LIGHT INFLUENCE ON IN VITRO ANTHOCYANIN PRODUCTION IN THREE CRANBERRY *(Vaccinum macrocarpon)* CULTIVARS

J.U. Toledo*, M.A.L. Smith, and L. Art Spomer. Dept. of Horticulture, University of Illinois, Urbana, Illinois 61801

The influence of spectral irradiance on in vitro anthocyanin production in white friable callus of cranberry cultivars 'Stevens', 'Searles', and 'Ben Lear' was examined by modifying cool white fluorescent lamp emission. Filters were used to shift spectral balance to blue, yellow, and red wavelengths at different PPF levels within a span of 30 to 150 $\mu$mol $m^{-2}s^{-1}$. White, friable, dark-grown calli—originally derived from shoots and leaves of shoot culture stock plants—were maintained approximately 6 months with subculture every 4 wk. Uniform callus masses were then subcultured to pigment induction medium and transferred to treatment microenvironments. Visual and machine vision analysis of pigmentation was assessed weekly for one month. Higher PPF levels stimulated the most rapid anthocyanin synthesis. Calli in the blue treatment produced the greatest pigmentation within the first two weeks. All three cultivars responded similarly to the treatments, however, pigmentation was slightly more intense in 'Ben Lear' at higher PPFs. Results indicate spectral irradiance significantly affects anthocyanin synthesis in cranberry callus cultures, and suggest that manipulation of the physical microenvironment is an important consideration in development of efficient in vitro natural pigment production systems.

024

EFFECT OF TISSUE AND EXTRACTS FROM CROWN GALL-RESISTANT AND-SUSCEPTIBLE VITIS GENOTYPES ON VIR INDUCTION IN AGROBACTERIUM VITIS

E.W. Stover[1]*, H.J. Swartz[1], and T.J. Burr[2]
[1] Dept. of Horticulture, Univ. of Maryland, College Park MD 20742
[2] Dept. of Plant Pathology, Cornell Univ., NYAES, Geneva,NY 14456

A GUS marker was used in earlier experiments to show that crown gall resistant Vitis genotypes show significantly lower rates of transformation by A. vitis than the crown gall susceptible Vitis vinifera. In recent experiments a reporter gene (lacZ) fused with the virB promoter was used to determine whether the lower frequency of transformation resulted from reduced induction of Agrobacterium vitis virulence (vir) genes. With some A. vitis strains, addition of medium conditioned with grape tissue enhanced vir induction by the known inducer acetosyringone and significant vir induction also resulted without addition of acetosyringone when grape tissue was included in the induction medium. Enhancement of vir induction by grape extracts was not correlated with genotypic susceptibility to crown gall.

025

AGROBACTERIUM-MEDIATED TRANSFORMATION OF *SALPIGLOSSIS SINUATA* L.

Lijuan Wang*, Nian-Qing Shi, Zongming Cheng, and Chiwon W. Lee, Department of Horticulture and Forestry, North Dakota State University, Fargo, ND 58105

Leaf discs of *Salpiglossis sinuata* L. were infected with disarmed *Agrobacterium tumefaciens* strain LBA 4404 carrying $\beta$-glucuronidase (*GUS*) gene and kanamycin resistance. Plantlets were regenerated from the leaf discs cultured on Murashige and Skoog (MS) medium supplemented with 10 $\mu$M kinetin and 1 $\mu$M naphthaleneacetic acid (NAA) plus 300 mg/liter kanamycin. The plantlets were then rooted on the MS medium containing the same concentration of kanamycin plus 2 $\mu$M NAA without kinetin. The histochemical assay showed that the regenerated plants were *GUS* positive. A Southern blot test is underway to determine the stability of the transferred genes in the regenerated plants.

026

A POSSIBLE DWARFING CHIMERA PRESENT IN A DWARF TRUMPET VINE, *CAMPSIS SP.*

Wayne A. Mackay*. Texas A&M University Research and Extension Center, 1380 A&M Circle, El Paso, TX 79927.

Actively growing shoots were collected from a mature dwarf trumpet vine in central Texas and successfully micropropagated. Plantlets were transferred to the greenhouse and acclimatized to in vivo conditions. Of the first 150 plants transferred to the greenhouse only two dwarf plants were recovered. The vigorous plants had altered leaf morphology and size, number of nodes to first flower, and internode length. However, flower morphology was unchanged. Conventional cuttings have now resulted in the recovery of several plants with both dwarf and vigorous phenotypes on the same plant. These results suggest the dwarf phenotype of the parent plant is controlled by a dwarfing chimera.

027

USING ANTIVIRAL COMPOUNDS AGAINST CYMBIDIUM MOSAIC VIRUS IN ORCHID TISSUE CULTURE

K. Porter* and A.R. Kuehnle. University of Hawaii. 3190 Maile Way, Room 102, Honolulu, HI 96822. (808) 956-2163. [Fax (808) 956-3894]

Dendrobium 'Uniwai Mist' (UH800) protocorm-like bodies (plbs) infected by Cymbidium mosaic virus (CyMV) were grown in Vacin and Went liquid medium supplemented by 15% coconut water with one of four antiviral compounds: ribavirin (virazole), cycloleucine, 3-deazauridine, and dithiouracil. After 5 weeks of treatment, 0.2 mM dithiouracil reduced



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CyMV to non-detectable levels and 0.05 mM 3-deazauridine lowered CyMV concentration by 66%. Both 0.2 mM dithiouracil and 0.05 mM 3-deazauridine resulted in smaller, darker green plbs and ~10% dead tissue as compared to the control. Virus concentration resumed to previous levels by 5 weeks after treatment with dithiouracil was discontinued. Ribavirin at 0.1 mM lowered virus concentration by 50% five weeks after treatment was stopped. 0.05 mM and 0.15 mM dithiouracil and 0.01 mM, 0.05 mM, 0.08 mM, 0.5 mM, and 0.75 mM ribavirin had no effect on virus concentration. 0.5 mM and 0.75 mM ribavirin resulted tissue death.

## 50 ORAL SESSION 4 (Abstr. 028–031) Cross-commodity: Photosynthesis

028

GROWTH AND GAS EXCHANGE FOR TISSUE-CULTURED VERSUS BUDDED TREES FOR TWO CULTIVARS OF RED MAPLE (ACER RUBRUM L.)

Jeff L. Sibley*, D. Joseph Eakes, Charles H. Gilliam, and William A. Dozier, Jr., Department of Horticulture, Auburn University, AL 36849

Growth of budded red maples 'Franksred' (Red Sunset TM) and 'October Glory' was compared to the same cultivar from tissue culture. Similar size trees, from a single nursery source, were container grown under standard nursery practices for 18 months. In March 1990, trees were field planted in central Alabama. Drip irrigation has been provided for each tree. Height and caliper measurements have been taken annually. Gas-exchange measurements were taken to evaluate net photosynthesis, transpiration, and stomatal conductance capacities with a portable photosynthesis system for these red maple selections. No differences in growth and gas-exchange between the budded trees and their tissue culture counterparts are evident following three years in the field.

029

PARTITIONING OF PHOTOASSIMILATES IN AVOCADO (*Persea americana* Mill.) DURING FLOWERING AND FRUIT SET

Thomas L. Davenport, Susan F. Finazzo, and Bruce Schaffer, University of Florida, IFAS, Tropical Research and Education Center, 18905 S.W. 280 St., Homestead, FL 33031, U.S.A.

The distribution of recent photoassimilates was examined in avocado (*Persea americana* Mill.) to assess competition for photoassimilates between developing inflorescences, fruitlets and vegetative shoots. Experiments were conducted before and during flowering, fruit set, and the transition from sink to source of developing vegetative shoots. Mature leaves, located proximal to developing reproductive organs, and developing leaves located distal to those organs were exposed to a one-hour pulse of $^{14}CO_2$. Translocation of radiolabeled assimilates was monitored over time and among organs. Overall distribution of assimilates was dependent on dry mass of tissues regardless of organ type. Flowers and fruitlets did not demonstrate greater sink strength than non-autotrophic leaves. Organs receiving assimilates were in phyllotactic alignment with source leaves. Photoassimilates were never limiting although flower and fruitlet abscission occurred during and after this competitive period. Our results indicate that carbohydrate availability is sufficient to support the growth of both developing fruitlets and leaves during early stages o reproductive development, and it did not limit fruitlet growth nor stimulate fruitlet abscission.

030

RESPONSE OF CROP PHOTOSYNTHESIS TO $CO_2$, TEMPERATURE, AND LIGHT: EXPERIMENTATION AND MODELING

Y. R. Reddy,* L. B. Pachepsky, and B. Acock, USDA-ARS Systems Research Laboratory, Bldg. 007, Rm. 008, BARC-West, Beltsville, MD 20705

Increasing atmospheric carbon dioxide concentration [$CO_2$] is expected to result in a $CO_2$ level of 600 $\mu L\ L^{-1}$ sometime during the 21st century, which will likely affect global climate primarily by increasing air temperature 3-6°C. Several studies were conducted on the interactive effects of [$CO_2$] and temperature in various combinations on cotton photosynthesis, respiration, transpiration, water use efficiency, and dry matter accumulation. The data were used to develop and test various types of photosynthesis models. The dependence of canopy light utilization efficiency and canopy conductivity for $CO_2$ transfer on temperature and $CO_2$ concentration was determined. The complete model of $CO_2$ exchange for cotton as a function of environmental factors contains 7 parameters. Methods of validation, parameterization, and comparison of photosynthetic models are described.

031

GROWTH AND PHOTOSYNTHESIS STUDIES OF ONCIDIUM ORCHID

Hew C.S. and W.H. Yong, Botany Department, National University of Singapore, Lower Kent Ridge Road, Singapore 0511.

The growth and photosynthesis of Oncidium Goldiana, a popular tropical orchid for cut flower production, have been studied. Four main developmental stages of Oncidium Goldiana were identified: bud stage, plantlet stage, unsheathing stage and pseudobulb stage. Pseudobulb formation occured during the unsheathing stage which was closely followed by the formation of inflorescence. The pseudobulb of Oncidium Goldiana is of heterblastic type and lacks stomata.

Oncidium Goldiana is a $C_3$ shade plant based on Chl a/b ratio, $CO_2$ compensation point, postillumination $CO_2$ outburst and light saturation. The rate of photosynthesis increased with the development of the inflorescence and auxillary bud. Pseudobulbs contain chlorophyll but show no sign of gas exchange in light and dark. However it fixes $CO_2$ in light with the partial removal of cuticle.

## 51 ORAL SESSION 5 (Abstr. 032–039) Cross-commodity: Breeding and Genetics I

032

EVALUATION OF SOMACLONES REGENERATED FROM LEAVES OF 'THORNLESS EVERGREEN' BLACKBERRY

Margaret A. Norton* and Robert M. Skirvin, University of Illinois, Department of Horticulture, Urbana, IL 61801

Plants were regenerated in vitro from intact lamina of Rubus laciniatus Willd. 'Thornless Evergreen' (TE), a chimeral thornless form of 'Evergreen' blackberry, which carries a thornless gene only in its epidermal tissue. Leaves without petioles or axillary buds were harvested from proliferating cultures and explanted onto modified Murashige and Skoog (MS) medium with various levels of BA, NAA and thidiazuron (TDZ). TDZ gave more consistent regeneration than BA. Up to 100% regeneration was observed with 0.2 $\mu$M TDZ plus NAA (0.25 or 1.0 $\mu$M) or 0.1 $\mu$M TDZ plus 1.0 $\mu$M NAA.

Regenerants from chimeral TE and a pure thornless somaclone (IL 6-6), were classified according to stem and petiole morphology and presence or absence of prickles. Most (74%) of the regenerants from chimeral TE showed marked stem and petiole twisting compared to 4% of the regenerants from IL 6-6. The plants with straightest petioles tended to have the most prickles. These regenerants have been field planted. Additional observations of these regenerants will be discussed.



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033
RFLP ANALYSIS OF DIVERSITY AMONG OPEN-POLLINATED POPULATIONS OF ONION (*ALLIUM CEPA* L.)
Ockyung H. Bark*, Michael J. Havey, USDA-ARS, Dep. of Horticulture, Univ. of Wisconsin, Madison, WI 53706,

Restriction fragment length polymorphisms (RFLPs) in the nuclear genome were used to assess genetic diversity among cultivated open-pollinated populations (OPs) of bulb onion (*Allium cepa* L.). Twenty OPs of contrasting day-length responses [long (LD) and short (SD) day] were examined with 104 random cDNA probes and two to four restriction enzymes. Sixty-one probes detected polymorphisms among the OPs for at least one restriction enzyme. Parsimony and cluster analyses were completed and no distinct grouping was observed between LD and SD OPs. Parsimony analysis generated a consensus tree that grouped all but two LD OPs and their relationships to the SD OPs were not resolved. Cluster analysis grouped all but three LD OPs and the distances from that group to the others were not greater than those among LD or SD OPs. These results suggest that LD and SD onions do not represent distinct germplasm sources and LD OPs possess a more narrow genetic background. The paucity of unique fragments among OPs indicates that phenotypic variation, e.g., day-length response or bulb color or shape, does not reflect diverse sources of germplasm.

034
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. Recently, molecular markers based on restriction fragment length polymorphism (RFLP) have been shown to be highly useful and efficient gene markers in other plant and animal species.

We have used a total of 40 carrot strains (inbreds, varieties, species) for this study. Genomic DNA probes cloned in pGEM (Promega) plasmid of *Escherichia coli* were hybridized with genomic DNA of restriction enzymes. We have found RFLP variation to be extensive in *Daucus*, even among related cultivation genetic stocks. The implications of these results in the germplasm diversity in *Daucus* will be discussed.

035
SCREENING FOR RESISTANCE TO *MELOIDOGYNE HAPLA* CHITWOOD IN CARROT (*DAUCUS CAROTA* L.)
Min Wang*, Warren H. Gabelman. Department of Horticulture, University of Wisconsin-Madison, 1575 Linden Dr., Madison, WI 53706

Nematodes are very difficult to control because they are soil-borne root-feeding organisms and there are many limitations in nematocide application. Four greenhouse experiments were conducted to determine differences in response of carrot (*Daucus carota* L.) lines to infestation caused by root-knot nematode (*Meloidogyne hapla* Chitwood). Plainfield loamy sand (Typic Updisamment; mixed, mesic), and 10 eggs per milliliter of soil inoculum concentration of *M. hapla* repeatedly provided an effective medium and measurement in discriminating differences in host-parasite responses. In vitro vial tests proved unsatisfactory. Significant differences were found among forty-two carrot lines on gall number rating, gall rating and root rating. Line 17 and line 19 consistently showed the most tolerance to infestation of *M. Hapla* evidenced by the lowest gall number (0 - 8 galls / seedling), lowest gall rating (1 - 1.83 / seedling) and lowest root rating (0.92 - 2.17 / seedling). Line 16 was the most susceptible one. High soil temperature potentially reduced carrot tolerance to *M. hapla*.

036
GENETICS OF RESISTANCE TO ALTERNARIA BRASSICICOLA IN BRASSICA OLERACEA
Stephen R. King* and Michael H. Dickson, NYS Agric. Exp. Sta, Department of Horticultural Sciences, Geneva, NY 14456

Initial screening indicated that 20° C and 100% RH using a 50,000 spores/ml concentration produced a severe test, but it was still possible to identify potential resistance. More than 600 Brassica spp. were screened at the 3-5 true leaf stage for resistance to Alternaria brassicicola, and selections were then subjected to a field screen. Disease severity scores ranged from 1 to 9, with 1 being most resistant and 9 most susceptible. Fourteen B. oleracea accessions representing cabbage, broccoli, cauliflower, kale, kohl rabi, brussels sprouts and chinese kale were selected as having potential resistance or tolerance. One B. napus accession was also selected for tolerance. Nine of the B. oleracea selections and three susceptible checks were included in a complete diallel. Resistance appears to be quantitative and partially dominant. Both general and specific combining ability effects were significant, but GCA is apparently more important in predicting the performance of the hybrid. The inheritance of resistance will be discussed.

038
STOMATAL ACRILIC MICRO-REPLICATIONS TO DIFFERENTIATE DIPLOID AND TETRAPLOID WATERMELONS (*Citrullus lanatus*)
Sergio F. Moreno-Salazar* and Jaime J. Martinez-Tellez, Departamento de Agricultura y Ganaderia, Universidad de Sonora. A.P. 1853, 83000 Hermosillo, Son. Mexico.

Early discrimination of diploids on breeding for seedless watermelon is time saving and economically important. The common method is pollen microscopic observation, it is time consuming and can not be executed on early stage. The objective was to prove the use of stomatal size and density to differentiate ploidy on plantlets. "Charleston Grey" and "Sugar Baby" diploids and colchicine-induced tetraploids of the same varieties were used. Stomata micro-replication made with acrilic varnish were used for measurements and correlated with individual ploidy. Significative differences were found on both size and density. "Charleston Grey" had larger stomata than "Sugar Baby". Tetraploids had larger stomata and lower density regardless of genotype. Stomata micro-replications is time saving and non destructive method to differentiate ploidy on early stages.

039
THE MORPHOLOGY OF FLORAL ORGANS OF CYTOPLASMIC MALE-STERILE LINE OF TUBER MUSTARD(*BRASSICA JUNCEA VAR. TUMIDA Tsen et Lee.*)
Chen Z. J.* Sun W. G. Wang B. L. Gao G. K. Zhejiang Agri. Uni., China 310029
Yu G. L. Hangzhou Vegetable Res. Insti., China 310004

The objective of the study is to clarify the morphology of floral organs of cytoplasmic male-sterile line of tuber mustard. The original material is the intra-specific hybrid of *Brassica juncea(L.)Czern et Coss × Brassica campestris L. ssp. pekinensis (Lour.) Olsson.* The flower of this materile is abnormal, especially with yellow-bud and fruitness(0.03 seed per silique), no nectary was observed. When backcrossed with tuber mustard($BC_1$ to $BC_7$), these obstracts have been solved. Yellow-bud has disappeared in $BC_7$, 12.4 seeds per silique are obtained when pollinated with maintainer line. The generation of $BC_6$ has 3.5 nectarys in average, ranged from 0 to 6. On the other hand, saccate bulge and papillae and external ovules were exsited in some stamens of sterile plant. The morphology of epidermal cells in saccuate bulge and basal portion of some stamens in $BC_6$ was similar to that of stamen with normal anthers in fertile plants. Nevertheless, a few pollens without outer walls are present on the stamen of male-sterile line.

## 52 ORAL SESSION 6 (Abstr. 040–047) Fruits/Nuts: Growth and Development

040
SORBITOL DEHYDROGENASE ACTIVITY AND CULTIVAR-SPECIFIC APPLE FRUIT GROWTH RATES
Douglas D. Archbold, Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington, KY 40546-0091

The activity of sorbitol dehydrogenase (SDH) may be the primary determinant of apple fruit carbohydrate accumulation, perhaps defining cultivar-specific fruit growth rates. During two intervals following June drop, fruit SDH activity of 5 cultivars was assayed along with measurements of fruit relative growth rate (RGR) and total soluble carbohydrate (TSC) and sorbitol levels of fruit cortex tissue. SDH activity varied over 2-fold among cultivars in interval 1 and nearly 7-fold in



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interval 2. SDH activity was not correlated to fruit RGR or cortex TSC level, but it was negatively correlated to cortex sorbitol level. Defoliation and girdling to restrict sorbitol import slowed fruit growth and reduced SDH activity to nondetectable levels. Growth resumption, presumably following phloem re-establishment in the girdled zone, was accompanied by substantial SDH activity. SDH activity appears to be cultivar-specific and may be influenced by substrate, i.e., sorbitol, availability. While SDH likely plays a key role in apple fruit carbohydrate accumulation, its activity alone may not determine cultivar-specific fruit growth rate.

041

DORMANT CARBOHYDRATE AND NUTRIENT RESERVES OF 'REDHAVEN' PEACH ON THREE ROOTSTOCKS UNDER TWO ORCHARD FLOOR MANAGEMENT SYSTEMS.

Danielle R. Ellis*, Gregory L. Reighard and William B. Miller, Dept. of Horticulture, Clemson Univ., Clemson, SC 29634-0375.

Trees of 'Redhaven' peach [*Prunus persica* (L.) Batsch] budded to Lovell, Bailey and Nemaguard rootstocks were grown with either bahiagrass or cultivated row-middles. Terminal shoots and roots were collected on four dates during 1991-92 (Nov. 15, Jan. 16, Feb. 26 and Apr. 1). On the April 1 collection date, trees grown with cultivated row-middles had higher levels of total soluble sugars and total carbohydrates in shoot tissue than trees grown with sod. There were no differences on any of the other dates. Orchard floor management did not affect the levels of Ca, Mg, K, P or Fe in shoots or roots. Trees on Nemaguard rootstock had significantly less starch and total carbohydrates in shoot tissue than those on Lovell on the last two collection dates. Shoot tissue of trees on Nemaguard and Bailey rootstocks had lower levels of K than those on Lovell. Sorbitol and total soluble sugar levels were higher in the root tissue of Lovell than Bailey and Nemaguard. Nemaguard had significantly higher levels of starch in root tissue than Lovell and Bailey. Nemaguard and Bailey had lower levels of Mg in root tissue than Lovell.

042

SIZE-CONTROLLING APPLE ROOTSTOCK EFFECTS ON FINAL TREE DRY WEIGHT AND TOTAL PRODUCTIVE EFFICIENCY

D.C. Elfving* and I. Schechter
Horticultural Research Institute of Ontario, Vineland Station, Ont. L0R 2E0 Canada

After 12 growing seasons, 'Starkspur Supreme Delicious' apple trees on 9 rootstock genotypes from very vigorous (MAC 24) to very dwarfing (M.27 EMLA) were divided into branches, trunk, rootstock shank, and roots, and total fresh and dry weights of each component determined. Final tree dry weight (DW) ranged from 2 kg (M.27 EMLA) to 90 kg (MAC 24). Both total top DW and total tree DW (including roots) were closely and linearly related to final trunk cross-sectional area (TCSA). Both total cumulative fruit fresh weight and DW per kg final tree DW increased curvilinearly with smaller final TCSA. The percentage of cumulative fruit DW plus final tree DW in fruit increased curvilinearly with smaller final TCSA. Although 9 distinct rootstock genotypes of widely different vigors were included, the close relationships of tree DW and the distribution of DW between fruit vs. wood to final TCSA suggested that rootstock effects on both vigor and productivity were mediated through a single overall mechanism.

043

APPLE BUD DEVELOPMENT AS INFLUENCED BY ROOTSTOCK

Peter M. Hirst* and David C. Ferree, Department of Horticulture, Ohio Agricultural Research and Development Center, The Ohio State University, 1680 Madison Avenue, Wooster, OH 44691

Apple flower formation was studied on mature 'Starkspur Supreme Delicious' apple trees growing on 5 rootstocks: B.9, M.26 EMLA, M.7 EMLA, P.18, and seedling. In 1991 and 1992 buds were sampled from the previous seasons growth and dissected. In 1991 10-20% of the buds from trees on M.26 EMLA, P.18 and seedling rootstocks formed flowers whereas flowers were evident in about 50% of the buds from B.9 and M.7 EMLA trees. In 1992 however, over 90% of buds from trees on all rootstocks formed flowers. Despite very different environmental conditions and degree of flower formation, flower differentiation occurred between 80-110 days after full bloom in both years and among all rootstocks. The critical number of nodes present in buds prior to the appearance of flowers was 18-19 and was not influenced by rootstock. Increases in node number over the course of a season was primarily due to increases in the number of bracts present in the bud. In 1991 (a season characterized by high temperatures and low rainfall) buds from trees growing on B.9 and M.7 EMLA rootstocks exhibited a higher final node number and a greater degree of flower initiation than buds from other trees, but no differences were observed during the more favorable conditions in 1992.

044

CULTIVAR VARIATIONS IN APPLE WAX COMPOSITION

Belding, R.D.*, S.M. Blankenship, and E. Young, Department of Horticultural Science, Box 7609, North Carolina State University, Raleigh NC 27695-7609

Apple cuticular wax is the primary environmental interface between the fruit and pathogens or protectant chemicals. Analyses have shown quantitative and qualitative differences in wax of apple cultivars grown in various environments. Of the twelve major wax components, seven exhibited significant variations between Golden Delicious(GD) and Red Delicious(RD) cultivars in all three years. Of these seven components, two compounds occur in greater concentrations in RD than in GD cultivars, one which elutes soon after hexacosanol comprises 10 to 15 % of the RD wax composition verses less than 0.5 % in GD. The other compound comprised 5% of the RD wax verses 1-2% in GD. The other five compounds were found in greater concentrations in GD than RD cultivars. Tetracosanol and another early eluting unknown compound each make up 1 to 3.5 % of GD wax composition while appearing in only trace amounts in RD cultivars. Hexacosanol and a third later eluting unknown each constitute 2 % of GD while concentrations in RD were consistently 1 % or less. Ursolic acid appears as two isomers, the first isomer constituted 12 to 16 % of GD wax and only 8 to 9 % of RD cultivars. Nonacosane and the major isomer of ursolic acid constituted 50 to 70% of the total wax of each cultivar and were not significantly different.

045

BRANCH DEVELOPMENT AND INDUCEMENT IN APPLE

David R. Ouellette* and Eric Young, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

One-year-old unbranched whips of 'Empire' apple (*Malus domestica* Borkh.) on MM.111 and M.26 rootstocks were planted in November 1991 and March 1992 in an eastern Piedmont and western Mountain site of North Carolina. Trees were subjected to one of five branch-inducing treatments: (1) notching: removing a thin band of bark above each bud; (2) 'knip boom': removing emerging apical leaves of the leader at regular intervals; (3) bending: tying whip to horizontal position, tying horizontally to opposite side four weeks after budbreak, and setting upright after another four weeks; (4) renewal: after a mid-season heading cut, tipping a weak lateral and setting upright to serve as a new leader; or (5) control: heading whip 30 inches above the graft union. After one year of growth, trees with M.26 rootstocks had more, slightly longer laterals than those with MM.111. Notching resulted in a much greater number of laterals than the control treatment, but increased branch length only in fall plantings. Bent trees had fewer and shorter laterals by mid-season than those of control trees. Although branch number and length did not differ from that of the control by the end of the season, bending resulted in shorter, asymmetric trees. Knipping and lateral renewal quickly led to the development of many laterals on current season growth, but were less effective later. Overall, planting date did not influence tree height, branch number, or branch length.

046

GROWTH AND ANATOMY DIFFERENTIATE ABORTING FROM NON-ABORTING FLOWERS AND FRUITS IN PECAN

I. Yates*[1], and D. Sparks[2], [1]USDA-ARS, Russell Research Center, P.O. Box 5677, Athens, GA 30613, [2]Department of Horticulture, University of Georgia, Athens, GA 30602

Growth and anatomical variations were compared between aborting and non-aborting pistillate flowers\fruits for the four physiological drops common to pecan. Size differences were larger between aborting and non-aborting flowers\fruits during early than late season drops. Flowers aborting during first drop typically had retarded development of the integument. Embryo sacs were invaginated in second drop fruits and distended in non-aborting fruits. Nucellar tissue and coencytic endosperm persisted in third drop fruits; whereas, nucellar tissue was degraded and the embryo surrounded by cellular endosperm in non-aborting fruits. The major defect in aborting fruits in the fourth drop was aberrant embryo development. Thus, aborting flowers\fruits had anomalies in the development of nonembryonic tissue during the first three drops and of embryonic tissue at the fourth drop.



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047

POLLEN-STIGMA INTERACTIONS IN HAZELNUT

Cheryl R. Hampson*, Anita N. Azarenko and A. Soeldner, Dept. of Horticulture, Oregon State University, Corvallis, OR 97331

Although genetic studies have demonstrated that hazelnut (*Corylus avellana* L.) possesses sporophytic self-incompatibility, the pollen of this woody species is bicellular and potentially long-lived, a feature more typical of gametophytic self-incompatibility. Reports of the behavior of incompatible pollen on stigmatic surfaces conflict. Our objective was to better characterize pollen-stigma interactions in this species. Female flowers were left unpollinated, or pollinated with compatible or incompatible pollen, fixed at time intervals up to 24 hrs., and then examined using scanning electron microscopy. The stigmatic surface was of the "dry" type. Emerged styles were completely covered with elongate, rounded stigmatic papillae. Compatible pollen hydrated within 2 hrs. of pollination, and started to germinate after 4 hrs. Penetration of the stigma was intracellular in some cases. Although compatible pollen also hydrated within 2 hrs., many grains never germinated. When germination did occur, pollen tube emergence was delayed until at least 8 hrs. Incompatible pollen tubes were distorted and did not penetrate the stigmatic surface.

## 53 ORAL SESSION 7 (Abstr. 048–054) Collegiate Branch Forum I

048

THE SFASU ARBORETUM - THE FIRST SEVEN YEARS

Dana A. Hill* and D. L. Creech, Department of Agriculture, PO Box 13000, Stephen F. Austin State University, Nacogdoches, TX 75962

The ten acre SFASU arboretum borders LaNana creek, the horticulture facilities and Agriculture building. SFASU, known as the "university among the pines," is the only university in Texas with a functional arboretum. The historical perspective of the arboretum is an interesting study of development, one that underlines the importance of prudent use of resources and limited funds in horticulture planning. The arboretum's mission is to promote the conservation, selection and use of the native plants of Texas and to encourage diversity in the urban landscape philosophy of the region. The arboretum serves as an outdoor living laboratory and is home to many uncommon, unusual, and difficult-to-find species and cultivars, many never tested in Texas until recently. Arboretum growth has been facilitated by a theme garden by theme garden approach. Thirteen gardens are in place with several in various stages of construction. Development has been facilitated through a "Friends of the SFASU Arboretum", a few benevolent gifts and grants, volunteers and the enthusiasm of SFASU horticulture students.

049

LEAF GAS-EXCHANGE, WATER RELATIONS, AND IONIC RESPONSES OF SAPODILLA TO SALINITY

Michael V. Mickelbart, CALS, University of Guam, Mangilao, Guam 96923 (Thomas E. Marler, Faculty Advisor)

The influence of root zone salinity on leaf gas-exchange, water relations, and ion absorption of sapodilla [*Manilkara zapota* (L.) Royen] plants was studied in sand culture under greenhouse conditions to investigate the mechanisms of stress damage. Treatments consisting of a complete nutrient solution diluted to 1 $dSm^{-1}$ (control), or the control solution salinized to 12 or 20 $dSm^{-1}$ were administered from 16 Nov. 1991 until 29 Jan. 1992. The plants were arranged in a completely randomized design with six replications. Net photosynthesis of the plants receiving saline solutions began to decline within two weeks, and by 8 weeks was ca. 70 or 30% of that of control plants for the 12 or 20 $dSm^{-1}$ treatments, respectively. Salinity reduced apparent quantum yield (based on light response curves), photosynthetic $CO_2$ use efficiency (based on $CO_2$ response curves), leaf osmotic potential, and pre-dawn xylem potential of sapodilla plants. Dark respiration and sensitivity to photoinhibitory damage (based on chlorophyll fluorescence) were not influenced by salinity. Exposure to salinity also increased leaf tissue $Na^+$ and $Cl^-$ concentrations, and the $Na^+/K^+$ ratio.

050

EFFECTS OF COLD STORAGE AND RECONDITIONING ON ASCORBIC ACID, SOLUBLE PROTEIN, SUGARS CONTENT, AND ULTRA-STRUCTURE OF AMYLOPLAST MEMBRANES OF 'YUKON GOLD' TUBERS.

James A. Okeyo* and Mosbah M. Kushad, Department of Horticulture, VPI & SU, Blacksburg, VA 24061, USA.

Yukon Gold, a yellow-fleshed potato cultivar, was grown in Southwest Virginia and analyzed for ascorbic acid, soluble protein, and sugars (glucose, fructose, and sucrose) at harvest, after 6 weeks storage at 3 C, and following 2 weeks reconditioning at 25 C. Scanning and transmission electron micrographs were taken at each of the three stages to determine the effect of cold storage and reconditioning on the ultrastructure of amyloplast membrane. At harvest the tubers contained 154.0 mg/100 g ascorbic acid, 45.4 mg/g soluble protein, and 4.1 mg/100 g total sugar on dry weight basis. Cold storage resulted in more than 2.5 fold increase in ascorbic acid, between 4 and 9 fold increase in sugars, and a significant increase in soluble protein content. Reconditioning, however, decreased ascorbic acid, soluble protein and sugars. The ultrastructure of the amyloplast membranes remained intact throughout the storage period.

051

IDENTIFYING THE OPTIMUM TEMPERATURE AND TIME FOR AERATED WATER SOAK TREATMENT TO STIMULATE RED OAK ACORN GERMINATION

Hurt, N.*, D. Struve and M. Bennett, Department of Horticulture, 2001 Fyffe Ct., Columbus, OH 43210

Earlier work demonstrated that red oak acorns subjected to an Aerated Water Soak (AWS) treatment had germination characteristics similar to osmo-conditioned vegetable seeds; acorn germination was accelerated and more uniform than untreated seeds. However, the optimum AWS time and temperature are unknown. Stratified bulk collections of red oak acorns were subjected to a factorial combination of AWS times (0, 3, 6, 9, 12 or 15 days) and temperatures (0, 5, 10 or 15°C). Following treatment, germination tests were conducted. Additional studies explored the effects of the AWS treatment combinations on seed respiration.

052

TOLERANCE OF CONTAINER-GROWN AZALEA AND LIRIOPE TO FOLIAR-APPLIED HERBICIDES THAT CONTROL NUTSEDGE.

R. Todd Hurt* and William K. Vencill, 3111 Miller Plant Sci. Bldg., Univ. of Ga., Athens, Ga. 30602.

*Rhododendron* L. 'Macrantha Orange' and *Liriope muscari* Bailey were treated with four herbicides at two rates each to determine phytotoxicity. The herbicide treatments were: imazethapyr at 280 and 560 g $ha^{-1}$, imazaquin at 280 and 560 g $ha^{-1}$, AC-263,222 at 35 and 70 g $ha^{-1}$, and MON12037 at 9 and 18 g $ha^{-1}$(treatments 1 - 8, respectively). Growth measurements and visual ratings were taken for the azalea and liriope at 28 DAT. No damage from any of the treatments was observed on the liriope. Azalea new growth reductions were (by treatment): (1) 83%, (2) 85%, (3) 87%, (4) 70%, (5) 57%, (6) 72%, (7) 44%, and (8) 24%. Azaleas receiving treatments 1-6 exhibited a loss of apical dominance resulting in multiple shoot formations below the terminal bud. The new leaves that emerged with treatments 5 & 6 were underdeveloped and chlorotic. Treatments 7 & 8 caused the least amount of stunting and did not induce any additional adverse effects.



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053
INDUCED MICRONUTRIENT TOXICITY IN KENTUCKY BLUEGRASS
Marcus B. Jackson* and Chiwon W. Lee, Department of Horticulture and Forestry, North Dakota State University, Fargo, ND 58105

Growth responses of Kentucky bluegrass (*Poa pratensis*) 'Touch Down' to elevated levels of micronutrients were investigated. Plants established in peat-lite mix in 10-cm pots were constantly fed with fertilizer solutions containing 0.5, 1, 2, 4, 6, 8, or 12 mM of boron (B), chloride (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), or zinc (Zn) for 7 weeks. The control solution had (in $\mu$M): 20 B, 0.5 Cu, 40 Fe, 10 Mn, 0.5 Mo, and 4 Zn. All treatment solutions had a standard macronutrient concentration. Foliar toxicity symptoms developed first in B treatments followed by Mo treatments. The lowest microelement concentrations that showed visual toxicity symptoms were: 0.5 mM B, 12 mM Cl, 1 mM Cu, 2 mM Fe, 0.5 mM Mo, and 1 mM Zn. A reduction in dry matter yield was evident when the nutrient solution contained 2 mM B, 4 mM Cu, 12 mM Fe, 2 mM Mo, or 4 mM Zn. Chloride and Mn did not alter biomass yield in the concentration range tested. Both the chlorophyll-*a* and -*b* contents decreased as B levels in the fertilizer solution increased. Chlorophyll contents increased with elevated levels of Fe in the fertilizer solution.

054
CLIENT REASONS FOR USE OF FOLIAGE PLANTS IN COMMERCIAL INTERIORSCAPES
Stan J. Lewis*. Department of Horticulture, University of Nebraska, Lincoln, Nebraska

Interior foliage plants are found in malls, small offices, restaurants, and other commercial ventures. This paper uses interviews/surveys to develop a clientele profile of users of interiorscapes in commercial interior design. Questions in the survey will discuss: number of employees, purpose/use/users of the plantscape, and costs of the green material. These responses will help identify the target market for foliage interiorscapes.

## 60 ORAL SESSION 8 (Abstr. 055–061) Floriculture: Marketing and Education

055
THE LANGUAGE OF FLOWERS.
J. McGrew and A.M. Hanchek*. Dept. of Horticultural Science, University of Minnesota, St. Paul, MN 55108

People often use flowers to communicate messages, yet little published work sheds light on the variables related to choice of flowers and intended messages. Pilot work using the semantic differentials found relationships between desired message and flower color/mass. In a full study, approximately 600 adults were questioned with two surveys that asked respondents to indicate choices and rating (Likert scale) of three or four arrangements of the same flower type that varied only on the dimension of color. Based on initial selection, they then answered a series of questions measuring emotional characteristics conveyed by the flowers and which arrangements they would choose to convey different emotional messages. Different flower colors implied significantly different degrees of masculinity or femininity, formality, novelty, and perceived value. Blue-based flowers were the least attractive, would not be frequently used to convey emotional messages, and when selected, would primarily convey a romantic message. Results were not gender-dependent. This research has implications for flower breeders, growers, and retailers.

056
SUPERMARKET FLORAL DEMONSTRATIONS INCREASED FRESH FLOWER INVENTORY
B.K. Behe* and L.M. Beckett, Department of Horticulture and Alabama Agricultural Experiment Station, 101 Funchess Hall, Auburn University, AL 36849-5408

Consumers' first-hand experience with products can increase their knowledge, which can stimulate sales. The purpose of this study was to determine if in-store floral demonstrations would increase fresh flower inventory (a measure of sales). Demonstrations were conducted for eight weeks on consecutive Fridays and Saturdays in September and October, 1992, in eight stores of a mid-western supermarket chain. Four test and four control stores in the same market area participated. Trained demonstrators contacted 18,418 consumers during 512 hours of demonstrations and distributed 4450 fresh flowers and 15,216 packets of floral preservative. After 11 weeks of monitoring, we observed a 28% increase in the average fresh flower inventory of demonstration stores compared to control stores ($P = 0.0750$). Supermarket in-store floral demonstrations increased average fresh flower inventory.

057
COMMERCIAL ACCOUNTS ARE AN IMPORTANT SEGMENT OF THE RETAIL FLORIST MARKET
L.J. Anderson*, B.K. Behe, C.F. Deneke, K.C. Sanderson Department of Horticulture and Alabama Agricultural Experiment Station, 101 Funchess Hall, Auburn University, Alabama 36849

Businesses purchase products and services like consumers, yet commercial floral purchases are undocumented. The purpose of this study was determine how businesses purchase flowers and the importance of commercial accounts to the retail florist. Two surveys were conducted in 1992; one was directed to retail florists and the other was directed to commercial businesses. The florist-directed survey addressed questions pertaining to general characteristics of the florist and their commercial accounts. The business-directed survey addressed questions pertaining to their firms's floral purchases. An average 31% of 1991 retail florist gross sales was accounted for by commercial accounts. Florists spent an average three hours weekly recruiting commercial accounts. Fifty seven percent of commercial purchases were fresh flowers. Commercial purchases of flowers are an important segment of the retail florist market.

058
INFORMATION SEARCH PATTERNS OF PERENNIAL PLANT CONSUMERS
W. Timothy Rhodus* and Laura Widhalm, The Ohio State University, Department of Horticulture, 2001 Fyffe Court, Columbus, OH 43210.

A declining number of knowledgeable sales staff in the garden center has increased the importance of signs and tags. Information that is provided by these mechanisms may influence purchasing decisions. Since performance of a plant product in a consumer's yard affects their satisfaction level, it is necessary to effectively assist their information collection and decision process.

Horticultural consumer behavior studies regarding information search patterns have not been done before. An experiment using an information display board technique was used. Consumers were first evaluated on numerous consumer attributes. Then they were presented with 6 perennial plants and asked if this is a plant they would purchase for their own yard. The option to collect information about the plant was provided. Finally, consumer response to 11 plant attribute factors was determined. The degree, direction, and sequence of the consumer's information search was recorded and an overall pattern was discovered.



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059
SURVEY OF RETAIL GARDEN CENTER EMPLOYEE TRAINING IN ALABAMA
Mary B. Musgrove*, J. David Williams, Bridget K. Behe and Kenneth M. Tilt, Department of Horticulture, Auburn University, Auburn University, AL 36849

A survey was conducted with 130 retail garden centers in Alabama to assess personnel training. The 59 item survey was mailed to 472 employees of these garden centers on 1 June 1992 requesting the amount, frequency, and methods of training they had received from their current employer. 176 surveys were returned for a 37% response rate. 69% of employees received verbal policies and standards from their employer when hired, whereas only 37% were given a written job description of responsibilities. 42% of the employees had received some kind of formal training with 56% received all of their training on an individual basis. Of the employees who received training in small groups, it was performed one to three times among 47% of employees and more than 10 times with 25% of employees. Significant decreases were shown in the amount of training received between the first week and the end of the first six months on the job. The results suggest not enough emphasis is being placed on employee training in the management and operation of retail garden centers in Alabama.

061
DECISION CASES ENRICH LEARNING FOR STUDENTS AND GROWERS
Emily Hoover*, Doug Foulk, Dept. Hort. Sci., Univ. Minn., St. Paul, MN 55108, Melvin Stanford, Mankato State University, Mankato MN.

Decision cases have been used as an instructional tool in business education and are now being written for agricultural disciplines. Students are placed as the decision maker to solve managerial problems without having to experience the situation first-hand. In the assignment, the decision maker has to distinguish germane from unimportant facts, identify alternatives among several issues, and formulate strategies and solutions either individually or as a group. Decision cases allow students to become actively engaged in the analysis of the facts and details of the case, the selection of a strategy, and the refinement and justification of the chosen strategy. A sample case will be presented where an orchard manager must decide on a pest management strategy for an apple orchard. This case will be used to illustrate the strengths and weaknesses of the case approach.

## 61 ORALS SESSION 9 (Abstr. 062–069)
## Vegetable Crops: Culture and Management

062
WITHIN-ROW SPACING EFFECTS ON TRAITS OF IMPORTANCE TO MECHANICAL HARVEST IN PAPRIKA PEPPER
Brian A. Kahn*, James R. Cooksey, and James E. Motes, Department of Horticulture and Landscape Architecture, Oklahoma State University, Stillwater, OK 74078-0511

Several within-row spacings (WRS) were tested on paprika peppers (Capsicum annuum L.) grown at a standard between-row spacing of 0.9 m. The objective was to maximize marketable yield per hectare while minimizing plant size and lodging so as to facilitate mechanical harvest. Total and marketable fruit dry weights per hectare decreased linearly as WRS increased from 5 to 25 cm in 1990. The 20 and 25 cm WRS produced undesirably massive plants with a high rate of lodging. Fruit yields were unaffected by WRS of 5, 10, and 15 cm in 1991, but lodging and stem dry weight data continued to favor the higher populations. Two experiments performed without thinning in 1992 produced WRS comparisons of about 4.5 vs. 8 cm and 7 vs. 11 cm, respectively. Stem dry weights were highest with the wider WRS, but marketable fruit dry weights per hectare and lodging percentages were unaffected by WRS in either 1992 study. A target WRS of 10 cm (about 11 plants/m$^2$) is recommended for paprika intended for mechanical harvest. Net WRS <10 cm are preferable to those >10 cm.

063
THE EFFECT OF THE SOURCE OF PH-ADJUSTMENT ACIDS ON UPTAKE AND TRANSPORT OF THE IONS FOR CUCUMBER PLANTS GROWN IN NFT.
*U. A. El-Behairy, S.W. Burrage, A.F. Abou-Hadid and A.S.El-Beltagy. Department of Horticulture, Faculty of Agriculture, Ain-Shams Univ., 11241 Hadaek Shobra, P.O. Box 86 Cairo, Egypt.

An experiment was conducted to investigate the effect of using nitric acid, phosphoric acid and nitric : phosphoric 3:1 to adjust the pH in NFT solution on uptake and transport of phosphorus, zinc and manganese ions on cucumber (*Cucumis sativus*) plants cv. Farbiola. Phosphorus concentration was increased to about 450 ppm when phosphoric acid used to adjust the pH. Increasing phosphorus concentration in NFT solution did not increase % of phosphorus in the leaves, but increased it in the roots. As a result of increasing % of phosphorus in the root . Manganese and zinc transport were increased from the root to the leaves .

064
VEGETABLE DAMAGE REDUCTION WITH DECELERATORS
Dale E. Marshall*, USDA - ARS, Fruit and Vegetable Harvesting, Farrall Hall, Mich. State Univ., East Lansing, MI 48824-1323.

The handling of mechanically harvested vegetables typically results in significant impact damage (bruises, broken or splits) when falling 1.8 to 2.8 m into empty field transport vehicles. To reduce this damage, reinforced vinyl hammock designs were suspended 0.7 m above the bottom of the container on rubber elastic springs. As the vegetables filled the hammock it settled to the floor. The hammock and spring system provided cushioning and significant damage reduction compared to when vegetables directly impacted the bare floor. Field studies with the hammock showed a 65 to 80% damage reduction to the first 15 to 20 cm depth of carrots and onions and 50% reduction in pickling cucumbers and potatoes. Compared to active systems such as an air bag, passive decelerators are simple, relatively inexpensive and significantly reduce impact damage. The cost effectiveness depends on the number of fills per season. Typical frequency of use of high-lifts in carrots (30 to 35 times/day) will pay for the hammock system in 1 season. To maintain field quality for the consumer, the impact damage encountered in field harvesting and handling operations can and must be reduced.

065
EASTERN BLACK (*SOLANUM PTYCANTHUM*) INTERFERENCE WITH PEA.
Michael P. Crotser* and John B. Masiunas, Department of Horticulture, University of Illinois, Urbana, IL 61801.

Field and greenhouse experiments determined the critical period for eastern black nightshade control in processing peas and the effect of nitrogen on nightshade competitiveness. 'Spring' peas were drilled with a 18 cm between row spacing on May 29 and July 31. Nightshade at 10 plants m$^{-2}$ were transplanted at 0, 2, 4, and 6 weeks. Nightshade established at pea planting were removed at 2, 4, and 6 weeks. Nightshade emerging after pea establishment did not reduce yields. Pea yields were reduced when nightshade interference occurred for the first four weeks. The yield reduction was caused by fewer peas being produced per plant. In the greenhouse experiment, the proportion of nightshade and peas planted in 38 L pots and nitrogen levels were varied. Nitrogen had a significant effect on nightshade competitiveness with peas.

066
WINTER COVER CROPS INFLUENCE YIELDS, NEMATODES, AND SOIL-BORNE PATHOGENS IN SUSTAINABLE CANTALOUPE PRODUCTION
Kathryn E. Brunson*, Sharad C. Phatak, J. Danny Gay, and Donald R. Sumner, University of Georgia, Tifton, GA 31793

Winter cover crops were evaluated to determine their influence on yield, nematodes, and soil-borne pathogens in sustainable cantaloupe production during a two year period. Six cover-cropping regimes, including a weedy fallow control, were tested in a replicated trial. Pesticide and commercial fertilizer



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inputs were significantly reduced in the cover crop treatments. No insecticides were needed throughout the study due to high populations of beneficial insects. Fertilizer inputs were only one-fourth the recommended rate used for conventional cantaloupe production. Populations of southern root-knot nematode (*Meloidogyne incognita*) and soil-borne pathogens *Rhizoctonia solani* and *Pythium* spp. were significantly higher in crimson clover and subterranean clover cover crops, yet yields were greater following crimson clover. Lowest yields and highest number of worm-damaged fruit occurred in the weedy control.

067

EVALUATION OF THREE DISEASE FORECASTING SYSTEMS FOR CONTROLLING EARLY BLIGHT ON TOMATO IN NEW JERSEY

W. P. Cowgill, Jr., M. H. Maletta,* and S. A. Johnston, Rutgers Cooperative Extension of Hunterdon County, Extension Center 4 Gauntt Place, Flemington, NJ 08822-9058

Three disease forecasting systems, **FAST, CUFAST** and **TOM-CAST**, were statistically evaluated at The Rutgers Snyder Research and Extension Farm in northwestern New Jersey for efficacy in the control of early blight (*Alternarina solani* ) on tomato. All three forecasting systems have generated reduced fungicide application schedules that significantly reduced fungicide input and provided adequate control for early blight. In 1991, using FAST and CUFAST, and in 1992, using all three disease forecasting systems, six fungicide applications were eliminated from the standard weekly spray schedule. Eliminating six fungicide applications resulted in an average reduction of 9 lbs a.i./A of fungicide with a calculated average cost savings of $200/A. In 1992, a demonstration trial with the CUFAST disease forecasting system in a commercial tomato planting eliminated six fungicide applications, provided commercially acceptable disease control and resulted in a $552/A reduction in production costs calculated with actual production records.

068

EFFECT OF GENOTYPE, PLANTING DATE, AND LEVEL OF MOISTURE AT HARVEST ON THE YIELD AND QUALITY OF GREEN-SHELLED BEANS

James Beaver* and Fred Fernandez, Agric. Expt. Stat., University of Puerto Rico, Mayaguez Campus, P.O. Box 5000, Mayaguez, PR 00681.

In Puerto Rico, harvesting beans (*Phaseolus vulgaris*) near physiological maturity enhances the value of the crop. Green-shelled beans are generally harvested 60-65 days after planting avoiding disease and pest problems that occur at the end of the growing season. It is also suited for multiple cropping and intensive rotations. Field experiments were conducted on the northern (Isabela) and southern (Fortuna) coastal plains of Puerto Rico to measure the effect of genotype, planting date and level of moisture of the seed at harvest on the yield and quality of green-shelled beans. The most adapted genotypes produced more than 5000 kg/ha of whole pods and 2200 kg/ha of green-shelled beans at both locations and growing seasons. Genotypes having different seed types were found to produce acceptable green-shelled yields. Whole pod yields were lower when harvested at the semi-dry stage than at the stage of development recommended for harvesting green-shelled beans. However, bean yields were similar when harvested at the green-shelled and semi-dry stages of development.

069

YIELD AND YIELD COMPONENTS ANALYSIS OF PEA CULTIVARS IN RESPONSE TO PLANTING DATE

Abdulla A. Alsadon* and Safwat O. Khalil, Department of Plant production, College of Agriculture, King Saud University, P.O.Box 2460, Riyadh 11451, Saudi Arabia

Lincoln and Rondo pea cultivars were evaluated under three planting dates, early (Oct. 21 or 22) midseason (Nov. 4 or 5) and late (Nov. 18 or 19) in 1989-90 and 1990-91 seasons,respectively.

While Rondo cv was superior in pod weight, pod length and 100- green seed weight, Lincoln cv. produced higher number of pods / plants and higher seed: pod ratio. Both cultivars had equal productivity . Early Planting was best for most of the studied traits. Pod weight and number of seeds / pod were not significantly affected by date of sowing. However,both traits were reduced with late planting.

During the growing season, yield increased up to the fourth harvest. However, in midseason and late planting, yield peaked by the second harvest. High correlations among yield attributes were obtained. These correlations were not affected by planting date.

# 62 ORAL SESSION 10 (Abstr. 070–077 Fruits/Nuts: Breeding

070

SEEDLESSNESS IN GRAPES: A MODEL FOR ITS INHERITANCE

Craig A. Ledbetter and Lorenzo Burgos*, Agricultural Research Service, Horticultural Crops Research Laboratory, 2021 S. Peach Ave., Fresno, CA 93727-5951

F1 populations of *Vitis vinifera* L. obtained from seeded by seedless crosses were studied to establish a model for the inheritance of the seedless triat. Two distinct types of stenospermic parents were used. Males were either obtained from seeded by seedless progenies, or obtained though *in ovulo* embryo cultures of seedless by seedless hybridizations. Based on the segregation ratios of progeny populations, which did not fit expected ratios for hypotheses previously proposed, an inheritance model for the stenospermic trait is proposed consisting of three dominant complementary factors. Three independently inherited genes are necessary to produce a seedless phenotype. A homozygous recessive condition at any of the three loci would produce a seeded phenotype. A high percentage of seedless progeny (36%-78%) was obtained when the male parents were selected from seedless by seedless progenies, which suggests that these males are homozygous for one or more dominant seedless alleles.

071

THE GENETIC CONTROL OF HYPERSENSITIVITY TO CHERRY LEAF-ROLL VIRUS IN WALNUT AND THE IDENTIFICATION OF DNA MARKERS FOR THE RAPID IDENTIFICATION OF RESISTANT SEEDLINGS.

Keith Woeste,* Robert Bernatzky, Gale McGranahan, Department of Pomology, Wickson Hall, U.C. Davis, Davis, CA 95616.

Blackline disease of walnut, caused by the Cherry Leafroll virus (CLRV), causes fatal necrosis at the union between English walnut (Juglans regia) scions and hypersensitive rootstocks. 'Paradox' hybrids between English walnut and Northern California black walnut (J. hindsii) are hypersensitive to CLRV. In 1983, 'Paradox' trees were backcrossed to J. regia and J. hindsii. Patch graft inoculations of 111 backcrosses, the parent species and 'Paradox' hybrids indicated that hypersensitivity to CLRV is inherited as a single dominant gene. Since breeding efficiency can be improved by the elimination of susceptible seedlings, we began a search for genetic markers tightly linked to CLRV resistance. DNA was sampled from the test population and from germplasm of both J. regia and J. hindsii. These samples were screened using randomly amplified polymorphic DNA (RAPD) markers and bulk segregant analysis. Over 360 random primers have been screened and two loci that are less than 10 map units from the hypersensitivity locus in this population identified. Efforts to find more closely linked markers that flank the hypersensitivity locus are continuing.

072

EXAMINATION OF VIRULENCE OF ISOLATES OF THE BITTER ROT PATHOGEN ON APPLE FRUIT

Yan Shi*, Curt Rom[1], and J.C. Correll[2], [1]Department of Horticulture and Forestry and [2]Plant Pathology, University of Arkansas, Fayetteville, AR 72701

Virulence of morphologically diverse isolates of Glomerella cingulata (anamorph: Colletotrichum gloeosporioides) and Collectotrichum sp. was examined by inoculating apple fruit. Three morphologically distinct fungal pathogens were examined on Red Delicious, Golden Delicious, or Idared. Fruit were inoculated by either placing a 100 ul spore suspension ($10^6$ spores/ml) into wounds or spraying the inoculum onto wounded fruit. All fruit were incubated at 25C on 100% RH. Free moisture was maintained on spray



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inoculated fruit. Virulence was quantified by measuring both lesion diameter and depth every 2-5 days for 2-4 weeks after inoculation. Overall, all of the teleomorphic isolates (G. cingulata) were significantly ($p=.05$) more virulent than the nonchromogenic or chromogenic isolates on fruit of all three cultivars. Genetically and morphologically diverse isolates of the bitter rot pathogen(s) are being selected and used to evaluate cultivar resistance to fruit rot.

073

ISOZYME VARIABILITY IN THE JAPANESE PLUM

David H. Byrne*, Dept. Horticultural Sciences, Texas A & M University, College Station, TX 77843-2133

The diploid cultivated plum, or the Japanese plum is a group of plants in which several plum species have been incorporated. Within the cultivated plum two germplasm pools are recognizable: the California and the Southeastern groups. A comparison of the isozyme variability at 11 loci between the two groups shows that the California germplasm is two to three fold less variable in terms of both percent of polymorphic loci and mean heterozygosity than the Southeastern germplasm. The greater isozyme variability within the Southeastern germplasm is due to the alleles derived from P. angustifolia and P. cerasifera which have been used as sources of disease resistance in the development of plums adapted to the humid plum growing areas of the southeastern United States.

074

ANTHOCYANIN MOSAICISM IN PEACH: EVIDENCE FOR AN ACTIVE TRANSPOSABLE ELEMENT

J. Chaparro, D. Werner*, R. Whetten, D. O'Malley, and R. Sederoff, Departments of Horticulture and Forestry, North Carolina State University, Raleigh, NC 27695-7609

Anthocyanin mosaicism in peach was investigated in the cultivar 'Pillar' and its progeny. Reversion of the unstable white flower (*w*) allele in 'Pillar' gave rise to mericlinal chimeras of non-pigmented and pigmented tissues. Self seeds obtained from chimeric shoots with green stems, red sepals, and bright pink flowers produced only anthocyaninless progeny, suggesting reversion in the LI cell layer. Mutant sectors with red stems, green sepals, and pale pink flowers produced about 50% pigmented progeny, suggesting reversion in LII tissue. Mendelian segregation of the revertant phenotype was demonstrated by crossing pollen from revertant red shoots (LII revertants) onto a stable anthocyaninless female of genotype *GrGrww*. Progeny segregated approximately 1:1 for anthocyanin production (red leaf color) and anthocyanin absence, respectively. Pollen from flowers on green-stemmed sectors produced predominantly anthocyaninless progeny when crossed to *GrGrww* females. Reversion of the unstable *w* allele in green-leafed progeny from these crosses was greater in LI than in LII tissue. Genetic evidence supports the contention that anthocyanin instability in 'Pillar' is due to transposable element activity.

075

DEVELOPMENT AND TESTING OF $F_1$ HYBRID PEACHES AS AN ALTERNATIVE PEACH PRODUCTION STRATEGY

Ralph Scorza* and Margaret Pooler, USDA/ARS Appalachian Fruit Research Station, 45 Wiltshire Road, Kearneysville, WV 25430

$F_1$ hybrids have not been used in tree breeding because 1) there have generally not been technologies for the production of homozygous lines; 2) in most species homozygosity leads to severe inbreeding depression and the inability to sustain inbred lines; and 3) in the case of tree fruits the long juvenile periods of most species makes it impractical to use $F_1$ hybrid seed for fruit production. Unlike most species, the peach may be particularly suited to the development of $F_1$ hybrid rootstock or scion varieties because it tolerates inbreeding and the juvenility period is relatively short (2-3 yrs). Doubled haploid peaches, including male sterile lines, were obtained from T.K. Toyama (HortScience 9:187). Intercrossing male sterile and fertile lines, we produced seven $F_1$ hybrid populations. $F_1$ trees fruited in the third growing season. Flowering, fruit production and fruit quality were uniform within each $F_1$ hybrid population. Fruit quality of the different $F_1$ hybrid lines ranged widely. Productivity was high and tree growth vigorous. These observations suggest the potential for the use of $F_1$ hybrids for peach rootstock and scion variety development.

076

PERFORMANCE OF SELECTED PEACH ROOTSTOCKS ON A SEVERE PEACH TREE SHORT LIFE SITE

Gregory L. Reighard* and William C. Newall, Department of Horticulture, Clemson University, Clemson SC, 29634, and William R. Okie and Thomas G. Beckman, USDA-ARS SE Fruit and Tree Nut Research Lab, Byron, GA 31008.

Two peach cultivars were budded in 1988 to seedlings from 10 open-pollinated peach and plum lines selected from a 7-year-old peach tree short life (PTSL) field test. Lovell and Nemaguard seedling rootstocks were also budded as controls. The trees were planted in 1989 on a non-fumigated PTSL site near Columbia, South Carolina. Highly significant differences in bloom date, trunk cross-sectional area (TCSA), suckering, bacterial canker infection, and PTSL death were found among the rootstock/scion combinations after four years. Bloom dates when compared to trees on Lovell were advanced by 1-6 days with trees on Blue Goose and BY7446 plums blooming the earliest. Scion TCSA on BY520-8 and BY520-9 peach rootstocks was significantly greater than on Lovell. The plum rootstocks BY7446, Blue Goose, and Edible Sloe had the smallest TCSA. Nemaguard, BY7446, and Edible Sloe had significantly more suckers per tree than Lovell. BY520-9 and Edible Sloe trees had significantly less bacterial canker infection than Lovell. BY520-9, BY7446, and Edible Sloe had the lowest PTSL mortality, and thus hold the most promise as potential rootstocks to replace Lovell on PTSL sites.

077

PROVISIONAL RELEASE OF BY520-9 PEACH ROOTSTOCK FOR THE SOUTHEASTERN UNITED STATES

W.R. Okie*, T.G. Beckman and G.L. Reighard [1]USDA-ARS, SE Fruit & Tree Nut Research Lab, P.O. Box 87, Byron, GA 31008 and [2]Department of Horticulture, Clemson University, Clemson, SC 29634

Most peaches in the Southeast are propagated on either Lovell [moderate longevity on peach tree short-life (PTSL) site, but root-knot nematode susceptible] or Nemaguard (short longevity on PTSL site; root-knot resistant) seedling rootstock. Rootstock BY520-9 appears to confer longer scion life than Lovell on PTSL sites and to be as resistant as Nemaguard to root-knot nematode, based on results from 9-year trials in Georgia and South Carolina followed by a 5-year budded trial in South Carolina. Parental line B594520-9 is a relic of USDA root-knot resistance breeding and traces back to a 1955 cross between a seedling of S-37 and Nemaguard. USDA and Clemson are making available bulked seed from superior selections of B594520-9, collectively known as BY520-9, to facilitate broad-scale industry testing. Plant Variety Protection (PVP) for BY520-9 is being applied for. Testing to select a single parental genotype continues at several southeastern test sites.

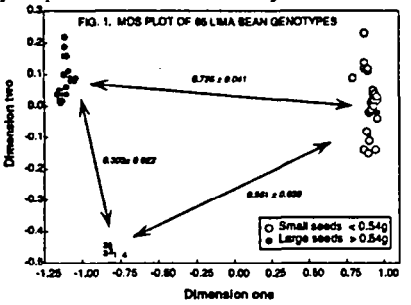
## 63 ORAL SESSION 11 (Abstr. 078–085) Vegetable Crops: Breeding and Genetics I

078

ORGANIZATION OF LIMA BEAN GERMPLASM BASED ON RAPD BANDING PATTERNS

Nienhuis, James*, J.B. dos Santos, J. Tivang and P. Skroch, Dept. of Horticulture, University of Wisconsin, Madison, WI 53706

Genetic distance was estimated among 65 *Phaseolus lunatus* genotypes, which included 4 large seeded and 8 small seeded cultivars, and 53 landraces from the the Caribbean, North, Central and South America. Based on 130 polymorphic RAPD bands two major clusters were observed among the landraces, which generally corresponded with small and large seed size (Fig. 1). The four 'Forkhook' type cultivars and a landrace from the USA formed a separate cluster, which was most closely related the the large seeded landraces.






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079

ORGANIZATION OF GENETIC DIVERSITY IN CULTIVATED COMMON BEAN (*Phaseolus vulgaris*) AS REVEALED BY RAPD MARKER ANALYSIS

Paul Skroch*, Jim Nienhuis, University of Wisconsin, Dept. of Horticulture, University of Wisconsin, Madison, WI 53706; Steve Beebe, CIAT, Cali, Columbia; Jim Meyers, University of Idaho Research and Extension Center, Kimberly, Idaho; and Phil McClean, North Dakota State University, Fargo, North Dakota.

More than 400 cultivars and breeding lines of *Phaseolus vulgaris* have been analyzed for 100 RAPD markers. The data set includes cultivars from all market classes of dry and snap beans, including entries from North America, Central America, and Europe. Genetic dissimilarities were calculated as the fraction of polymorphisms scored for each genotype pair. The distribution of genotypes revealed using principle components analysis and multi-dimensional scaling on the matrix of genetic dissimilarities agrees in general with phenotypic classification. We are currently studying the relationship of marker data to pedigree information. We are also examining individual marker and marker linkage distributions as they relate to the overall patterns of diversity.

080

MAPPING COMMON BLIGHT RESISTANCE LOCI IN PHASEOLUS VULGARIS L. USING RANDOM AMPLIFIED POLYMORPHIC DNA (RAPD) MARKERS

Geunhwa Jung[1]*, Paul W. Skroch[2], Dermot P. Coyne[1], James Nienhuis[2], and E. Arnaud-Santana[1], [1]University of Nebraska, Lincoln, Nebraska 68583-0724 and [2]University of Wisconsin, Madison, Wisconsin 53706

Common bacterial blight (CBB) disease, incited by Xanthomonas campestris pv phaseoli (Smith) Dye (Xcp) is an important disease of common beans. Low heritabilities and low genetic correlations were found previously for reactions to Xcp in leaves, pods, and seeds in recombinant inbred (RI) F6 lines from the cross 'PC-50 x XAN-159'. RAPD reactions were conducted on the above RI lines of known reactions to Xcp. 134 RAPD markers were mapped to 14 linkage groups using 70 F6 RI lines. Genomic regions involved in the genetic control of the traits were found using single-factor ANOVAs and regression analyses. For seed, pod and leaf reactions, 6, 2, and 5 putative QTLs were identified, which accounted for about 51%, 29%, and 57% of the phenotypic variation in CBB resistance. QTLs were generally independently distributed except for one linkage group with closely linked QTLs for resistance in all plant parts. Molecular marker results confirm previous phenotypic Xcp reaction findings and also may provide for more efficient selection for resistance in the different plant organs.

081

EVALUATION OF VIGNA UNGUICULATA GERMPLASM FOR INSECT RESISTANCE

Oyette L. Chambliss* and A. Gene Hunter, Department of Horticulture, Auburn University, AL 36849-5408

Germplasm accessions and advanced lines were evaluated for resistance to cowpea curculio, Chalcodermus aeneus, southern green stink bug, Nezara viridula, and leaffooted bug, Leptoglossus phyllopus, in a field planting in southeastern Alabama. A total of 300 entries were chosen based on reported resistance to these and other insects and diseases. Among six check lines with known curculio resistance, our best line, AU85-CCR-20, ranked in the top 1%, 'Freezegreen' ranked in the top 8%, and four of the six lines ranked in the top 17% of lines with no more than 2.0, 3.8, 5.5 larval exit holes/25 pods, respectively. Entries with less exit holes than AU85-CCR-20 were UCR191, PI 170859, and PI 218122 with 1.0, 1.0, and 1.3 holes, respectively. Eight lines with pod resistance to cowpea weevil, Callosobruchus maculatus, (92.3 to 99.9% larval mortality) were evaluated for curculio resistance, and four ranked in the top 32% with 7.0 or less exit holes/25 pods. Among curculio resistant lines, PI's 142779, 175959, 293468 and UCR168 had 10% or less of their pods destroyed by pod bugs.

082

INHERITANCE OF THE GREEN COTYLEDON TRAIT IN SOUTHERNPEA [VIGNA UNGUICULATA (L.) WALP.]

R. L. Fery* and P. D. Dukes, U. S. Vegetable Laboratory, ARS, USDA, 2875 Savannah Highway, Charleston, SC 29414-5334

The recently released cream-type southernpea cultivar Bettergreen exhibits a unique green cotyledon trait that allows harvest at the near-dry seed stage of maturity without loss of the seed's fresh green color. Progeny tests of plants from the parental, $F_1$, $F_2$, and backcross populations of the crosses 'Bettergreen'$^2$x 'Carolina Cream' and 'Bettergreen' x 'Kiawah' indicate that the green cotyledon trait is conditioned by a single recessive gene. The results of an allelism test indicate that this recessive gene is not allelic to the gt gene that conditions the green testa trait in the cream-type cultivar Freezegreen. We propose that the new gene be designated green cotyledon and symbolized gc. Seeds containing embryos homozygous for the green cotyledon gene are easily identified. This ability to select in the seed stage should greatly facilitate efforts to backcross the green cotyledon gene into cream-, pinkeye-, and blackeye-type cultivars.

083

MULTIPLE-DISEASE-RESISTANT LONG GREEN/RED CHILE.

B. Villalon. Texas Agricultural Experiment Station, 2415 E. Hwy 83, Weslaco, Texas 78596.

Long green/red peppers (chile), one of about 20 different domesticated Capsicum annuum L. types, has for many years been associated with the green fresh market, processing and dehydrated red chile industry in the southwest. Increased demand for green chile and for high red color chile powder, high vitamin C, and low caloric pepper product has stimulated production in Texas and other areas throughout the world. All known commercial long green/red chile are susceptible to viral, fungal and bacterial diseases. These pathogens are limiting factors in most pepper production areas throughout the world. The Texas Agricultural Experiment Station at Weslaco has developed several hundred mildly pungent, high red color inbred lines with resistance to tobacco etch virus, pepper mottle virus, potato virus Y, tobacco mosaic virus, tobacco ringspot virus, cucumber mosaic virus and Phytophthora capsici. Disease resistant lines of mildly pungent long fruited, medium thick wall chile are being advanced to cultivar status.

084

EVALUATION OF RESISTANCE TO ANTHRACNOSE IN CAPSICUM ANNUUM

Jian Hua Liu*, Y. Liu and Y. H. Yang, Hunan Vegetable Institute, Hunan Academy of Agricultural Sciences, Changsha, Hunan 410125, China.

Pepper seedlings in 4- or 5-leaf stage were inoculated by spraying the mixture of spore suspension (approximate $1X10^6$ spores/ml) of both Colletotrichum coccodes and C. capsici. They were then kept wet and incubated in greenhouse under 27-28C. Every plant was respectively examined and recorded for symptoms on leaves and stem on the 7th and 14th day after inoculation. Various varieties of pepper were finally compared in their disease indexes. 1,015 varieties of pepper were evaluated for their resistance to anthracnose. The results showed that 91 varieties (8.96%) were resistant, 174 (17.14%) tolerant, 582 (57.33%) susceptible and 168 (16.55%) highly susceptible. Some resistant varieties showed relative resistance to TMV and CMV as well.

085

MEDICINAL VEGETABLES IN GUIZHOU PROVINCE OF CHINA

Guangsho Ma, Guizhou Institute of Agricultural Sciences, Guiyang, Guizhou Province, P.R. of China

Guizhou, a mountainous province located in southwestern China, has a great diversity of species of wild plants due to its temperate climate and abundant rainfall. Since Guizhou is rich in wild vegetables, the mountaineers there tend to take wild vegetables as medicine instead of going to hospital when they are sick. For instance, they often use cochin-chinese asparagus to cure constipation, cudweed and britle-thistle to cure cough with sputa, shortlobed wormwood to cure epistaxis and melena, hirsute shiny to cure irregular menstruation of women, common self-heal to cure high blood pressure, longtube ground to cure common cold, purslane and Japanese clover to cure dysentery, etc. For the mountaineers, the wild herbs are both edible greens and medicine. Eating medicinal herbs is an excellent way of retaining healthy for the mountaineers. These medicinal herbs can prevent diseases and supply vitamins, minerals, cellulose and other elements necessary for normal and healthy development of human

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body. As a result, the mountaineers have good health and live long life. There are more than 100 species of wild plants which are both edible and medicinal in Guizhou province according to my research and investigation for 50 decades.

# 64 ORAL SESSION 12 (Abstr. 086–093) Cross-commodity: Growth and Development

086

OCTYLPHENOXY SURFACTANT-ENHANCEMENT OF NAPHTHYLENE ACETIC ACID (NAA) AND BENZYLADENINE (BA) PENETRATION THROUGH ISOLATED TOMATO FRUIT CUTICLES

Peter D. Petracek*, Moritz Knoche, Royal G. Fader, and Martin J. Bukovac, Horticulture Department, Michigan State University, East Lansing, MI 48824.

The cuticle is the primary barrier to the penetration of foliar applied chemicals. Recent studies indicate that octylphenoxy polyethoxylated surfactants (Triton X, TX) directly enhance cuticular permeability. An infinite dose diffusion system, which consisted of donor and receiver cells interfaced by a cuticular membrane (CM) enzymatically isolated from mature tomato fruit, was used to determine surfactant effect on growth regulator penetration. Steady state penetration of CM and dewaxed CM by the nondissociated forms of radiolabelled NAA and BA was followed successively after: (1) NAA or BA addition to donor cell, then (2) surfactant (0.1% w/v) addition to donor or receiver cell, and finally (3) surfactant addition to the other cell. The ratio of growth regulator permeances after to before surfactant addition ($P_{aa}$) was used to quantify the surfactant effect. In general, surfactants increased growth regulator penetration regardless of the location of surfactant addition, presence of waxes, or cuticle orientation to the donor solution (average $P_{aa}$: NAA + TX-45, 6.1; BA + TX-100, 2.1). Surfactant-enhanced penetration did not depend on growth regulator/surfactant copenetration since the enhancement was observed when the two components were in opposite cells. This suggested that the surfactant acted directly on cuticle. Transient state analysis of growth regulator sorption/desorption did not indicate a clear surfactant effect on either diffusivity or partitioning. However, latent effects of TX-45 on NAA penetration were seen also for sorption and desorption.

087

INVOLVEMENT OF CORK CELLS IN DEVELOPMENT OF EPICUTICULAR WAX FILAMENTS

Matthew A. Jenks* and Edward N. Ashworth, Department of Horticulture, 1165 Horticulture Building, Purdue University, West Lafayette, IN 47907-1165

Chemically-induced near-isogenic (*bm*) mutants of *Sorghum bicolor* with altered epicuticular wax (EW) provide a model system for elucidating ultrastructural mechanisms associated with EW production. Light and scanning electron microscopy reveal that tubular EW filaments are deposited over rounded papillae on the surface of modified epidermal cells-- cork cells. Transmission electron microscopy reveals that wild-type cork cell apical walls are sinusoidal, multi-layered, and possess an osmiophilic apical cap forming an intermediate layer between the inner and outer walls. Highly vesiculated cytoplasmic extensions appear directly beneath papillae. Whether osmiophilic globules within cork cell cytoplasm serve as precursors for EW is still unclear. Unique near-isogenic mutants bm-21, bm-22, and bm-38 with little papillar EW production have alterations in cork cell apical cap and vacuole development. Specific *Sorghum bm* gene mutations alter development of EW crystal morphology and cork cell ultrastructure.

088

IMMUNOCYTOCHEMICAL LOCALIZATION OF 22-KILODALTON POTATO PROTEINASE INHIBITORS

Sang-Gon Suh[1]*, Jun-Koo Cho[1], Hee-Don Chung[1], and David J. Hannapel[2]
[1]Department of Horticulture, Yeungnam University, Kyongsan 712-749, Korea
[2]Department of Horticulture, Iowa State University, Ames, Iowa 50011

Twenty-two kilodalton potato proteinase inhibitor (22-kD PPI) is synthesized as a pre-protein with a hydrophobic signal sequence of 40 amino acids. Using immunogoldcytochemistry we determined the subcellular localization of the 22-kD PPI. Using 22-kD PPI specific antibodies and GAR-IgG colloidal gold for electron-microscopical immunocytochemistry, the 22-kD PPI was found to be localized mainly in the vacuole and cytoplasm of both tubers and wounded leaves of potatoes (*Solanum tuberosum L*). Within the vacuole, label was found predominantly over the protein aggregates and protein cluster-like structure. Neither cell wall nor the intercellular space contained detectable levels of the 22-kD PPI. We found one basic residue with a hydrophobic core followed by a cleavage site for signal peptidase in the deduced amino acid sequence of the 22-kD PPI cDNA clone, p34021. A conserved glutamine, which is thought to be required for correct sorting in all vacuolar proteins sequenced to date, was also found in amino acid sequence derived from the 22-kD PPI cDNA clone, p34021.

089

CYTOCHROME AND ALTERNATE RESPIRATORY PATHWAY CAPACITIES OF PEACH EMBRYOS

Yerko M. Moreno and Anita Nina Azarenko*, Department of Horticulture, Oregon State University, Corvallis OR 97331-7304.

'Lovell' peach seeds were stratified for 0 to 12 weeks at 4°C under moist conditions. Differential Scanning Calorimetry (DSC) was used to study the respiratory capacity for the cytochrome (CP) and alternative (AP) pathway of the embryos during this period. Azide and SHAM titration curves were obtained by measuring the heat of metabolism produced by the excised embryos after vacuum infiltration with appropriate combinations of the two inhibitors.

Uninhibited total respiratory activity increased steadily with the stratification treatment. AP capacity of the embryos was higher than CP capacity for the first 4 weeks of stratification. Between 4 and 6 weeks, CP capacity increased markedly and after 6 weeks was at least 40% higher than AP capacity. This rise on CP capacity coincided with the point at which an increase in seedling vigor and germinative capacity was observed and is in agreement with previous studies suggesting a change in respiratory efficiency as being responsible for the increase in seedling vigor.

090

MODIFICATION OF MECHANICAL STRESS EFFECTS ON ELONGATION OF DARK-GROWN SOYBEAN BY $Ca^{2+}$ AND $K^+$

Patricia N. Myers* and Cary A. Mitchell, Purdue University, Center for Plant Environmental Stress Physiology, West Lafayette, IN 47907-1165

A single episode of thigmic (contact rubbing) stress applied to the apical hook of a dark-grown soybean hypocotyl results in a two-phase response: an initial rapid (s) cessation of elongation followed by a long (h) recovery. Increased $Ca^{2+}$ in the growth matrix from 1 to 5 mM increased the average pre-stress elongation rate from 22 μm $min^{-1}$ to 40 μm $min^{-1}$; further increases in $Ca^{2+}$ did not further enhance elongation rate. There was no effect of nutritional status on the initial rapid response to a single episode of thigmic stress; all seedlings stopped elongating within seconds regardless of nutrient status. However, seedlings cultured with higher levels of $Ca^{2+}$ recovered their pre-stress rate more quickly. Correlation of enhanced recovery with enhanced root development was observed for seedlings grown in 5 mM $Ca^{2+}$. Inclusion of 1, 5, or 10 mM $K^+$ in the growth matrix further reduced recovery time from ≥6 h to ≤3h. $K^+$ effects may be due to the ability of seedlings to adjust osmotically. It previously has been shown that seedlings have significantly less $K^+$ in their elongation zone following stress, and the osmotic potential of the expressed sap is lower than that of controls. Physiological and biophysical changes that occur in response to mechanical perturbations have potential for modification by nutritional status.

This project was supported in part by NASA grant NAG10-0093.

091

DIURNAL FLUCTUATION OF CARBOHYDRATE CONCENTRATION OF YOUNG WATERMELON PLANTS AS AFFECTED BY LIGHT QUALITY

Heather Hatt* and Dennis R. Decoteau, Department of Horticulture, Poole Agriculture Center, Box 340375, Clemson University, Clemson, SC 29634-0375

Young watermelon (*Citrullus lanatus* cv. Sugar Baby) plants were treated with end-of-day (EOD) Red (R), Far-red (FR), and Far-red followed by Red (FR/R) light for 15 minutes. Control plants had no EOD light treatment. FR light treatments influenced plant growth and development (i.e., petiole elongation, internode elongation, and reduced petiole angles). Plants were sampled every 4 hours for a 24 hour period from each light treatment. Tissues (petioles, leaves, stems, and cotyledons) were analyzed from each treatment and sampling time combination for soluble carbohydrate and starch concentrations. Results suggested that carbohydrate concentration, distribution, and diurnal fluctuation were affected by EOD light quality treatments. Petioles of FR treated plants contained the greatest concentration of glucose, fructose and total soluble carbohydrates, and the least concentration of stachyose and starch. Stems of FR treated plants had the least concentration of total sugars and starch. Petioles of R treated plants contained the greatest concentration of stachyose and the least concentration of glucose. The changes in concentration of the storage carbohydrate (starch) and breakdown products (fructose and glucose) of the translocated sugar (sucrose) may be correlated to active growth of petioles and stems in response to light quality.



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092
SWEETPOTATO CANOPY GEOMETRY
Wayne J. McLaurin and Stanley J. Kays Department of Horticulture, The University of Georgia, Athens, GA 30602-7273

The sweetpotato, unlike most vegetable crops, exhibits a vining growth habit where vertical development is sacrificed for rapid radial expansion. Considerable genetic diversity is present in vine length within the sweetpotato genepool. To test the relationship between the degree of vining (land area covered during the growing season) and yield, 5 vine length types (dwarf, bunch, normal, long and very long) were grafted on the same root stock ('Jewel'). At harvest, canopy diameter and area, root fwt and number, total vine length, and number of vines, leaves, missing leaves, nodes and flowers were determined as well as root, vine, leaf, petiole and flower dwt. Individual parameters were related to storage root development and harvest index. Total vine length ranged from 5.0m to 73.8m/plant, while vine number varied from 12.6 to 117.8 vines/plant. The total number of leaves/plant varied from 595 to 2680 while the percent leaf loss ranged from 17 to 38%. Root yield (fwt) was lowest for the dwarf vine type (593 g/plant) a1nd highest for the longest vine type (2716 g/plant).

093
SEED YIELD IN CULTIVATED NATIVE HERBACEOUS SPECIES
J.L. Bohnen* & A.M. Hanchek, Dept. of Horticultural Science, University of Minnesota, St. Paul, MN 55108

The Univ. of Minn. has undertaken a two year project to increase commercial production of native grass & forb seed. *Spartina pectinata* Link (prairie cordgrass), *Tradescantia ohiensis* Raf. (spiderwort), & *Dalea purpurea* Vent. (purple prairie clover) were noted by producers as having low seed yield & often low germinability as well. Field trials were conducted to compare yield of these three species in cultivation versus in a prairie matrix. Individuals were transplanted from a prairie into a cultivated plot in May 1992. The prairie plot was not modified, while the cultivated plot was fertilized, irrigated, weeded, & mulched. Yield components measured included number of inflorescences per plant, seed weight, & above-ground dry weight. *T. ohiensis* established readily & first season seed yield was significantly greater in cultivation than in the prairie. *S. pectinata* & *D. purpurea* in cultivation did not produce seed the first season; however, strong vegetative growth suggested that results similar to those achieved with *T. ohiensis* may be attained in subsequent growing seasons. Monocultural production of native species provides an opportunity to control inputs & competition & to utilize species-specific harvest practices.

## 65 ORAL SESSION 13 (Abstr. 094–101)
## Small Fruit: Growth and Development

094
INFLUENCE OF EVAPORATIVE COOLING AND HYDROGEN CYANAMIDE ON BUDBREAK, YIELD AND FRUIT MATURATION RATE OF PERLETTE GRAPEVINES
R. Neja*, N. Dokoozlian, L. Williams, and E. Walker, Univ. of Calif. Cooperative Extension, Riverside County.

A 3 x 2 factorial experiment was initiated in the fall of 1990 to study the interaction between evaporative cooling and hydrogen cyanamide on the budbreak, yield, and fruit maturation rate of Perlette grapevines grown in the Coachella Valley of California. Main plots consisted of evaporative cooling treatments [water applied continuously via overhead sprinklers for 0, 10, or 24 hours per day], and split plots consisted of hydrogen cyanamide applications [0 or 2% (v/v)]. Hydrogen cyanamide was more effective for the advancement of budbreak and fruit maturation than evaporative cooling in both 1991 and 1992. No additional advancement of budbreak and fruit maturation was observed when evaporative cooling and hydrogen cyanamide were combined compared to when hydrogen cyanamide was applied alone. Packable, unpackable, and cull yield per vine did not differ significantly among the treatments in 1991, while both evaporative cooling and hydrogen cyanamide reduced cluster number per vine and fruit yield in 1992.

095
LEAF AREA TO CLUSTER WEIGHT RATIO ON FRUIT VISUAL COLOR, CONTENTS OF TOTAL ANTHOCYANIN AND INDIVIDUAL ANTHOCYANINS OF RELIANCE GRAPES (*Vitis* hybrid)
Yu Gao* and Garth A. Cahoon, Department of Horticulture, OARDC/OSU, Wooster, Ohio 44691

Fruit color parameters including fruit red color, total anthocyanin content, and individual anthocyanins content in response to leaf area to cluster weight ratio (LACWR, $cm^2/g$), were investigated using Reliance grapevines grown in the field. Non-linear parametric models were used to describe the relationship between LACWR and fruit color parameters. The critical levels in LACWRs required for maximum fruit red color, total anthocyanin content, delphinidin-3-glucoside, cyanidin-3-glucoside, petunidin-3-glucoside, peonidin-3-glucoside, malvidin-3-glucoside, and cyanidin-3-(p-coumarin)-glucoside contents, were 7.85, 8.09, 7.85, 8.19, 8.52, 8.52, 9.25, 7.92, respectively. Delphinidin-3-glucoside (critical LACWR, 7.85) or cyanidin-3-(p-coumarin)-glucoside (critical LACWR, 7.92) showed much closer association with fruit red visual color than cyanidin-3-glucoside (critical LACWR, 8.19). Much higher LACWRs were required for the evolution of petunidin-3-glucoside, peonidin-3-glucoside, or malvidin-3-glucoside than for the fruit visual color. This indicates that petunidin-3-glucoside, peonidin-3-glucoside, or malvidin-3-glucoside contributed much less to fruit red visual color than delphinidin-3-glucoside, cyanidin-3-glucoside, or cyanidin-3-(p-coumarin)-glucoside.

096
BIOMASS ACCUMULATION PATTERNS IN A COMMERCIAL 'EARLY BLACK' CRANBERRY PLANTING
Carolyn J. DeMoranville*, University of Massachusetts Cranberry Station, P.O. Box 569, E. Wareham, MA 02538

Dry weight accumulations (area basis) in new shoots, old leaves, woody stems, roots, and fruit of 'Early Black' cranberry were determined seasonally for 1987 to 1989. The planting received 335 kg/ha of 10N-8.7P-8.3K per season. New shoot tissue accumulated dry mass at a rapid rate from late May until late July, and again in the late summer (stem lignification). Root biomass was variable, declining and increasing in a cyclic pattern. Apparently, cranberry roots are short-lived. At times of declining biomass, many decaying roots were found in the samples. The pattern of biomass accumulation in roots was opposite that of shoots with shoot:root varying during the season from 0.12 to 0.55. Over the entire season, root biomass accounted for >60% of the total biomass per unit area of cranberry bog. At this location, fruit made up 10% of standing biomass at harvest. Changing fertilizer dose affected new shoot weight and length and fruit production, but the effect on root biomass was not significant in the 3 years of the study.

097
CARBOHYDRATE METABOLISM IN $GA_3$-TREATED AND POLLINATED RABBITEYE BLUEBERRY FRUITS.
Raquel Cano-M.* and Rebecca L. Darnell, Horticultural Sciences Department, IFAS, University of Florida, Gainesville, FL. 32611.

Carbohydrate metabolizing enzymes and carbohydrate accumulation were examined in pollinated, non-pollinated and $GA_3$-treated blueberry fruit. Our hypothesis was that $GA_3$ induces fruit set in blueberry by increasing the carbohydrate metabolizing enzyme activity in the ovary with a subsequent increase in carbohydrate mobilization. FW of non-pollinated fruits increased little between 0-45 days, when abscission occurred. FW of $GA_3$-treated and pollinated fruits increased from 20 mg at anthesis to 1 and 2 g, respectively, at ripening. Insoluble invertase activity decreased from 15 µmol $gFW^{-1}h^{-1}$ at anthesis to 3 µmol $gFW^{-1}$ $h^{-1}$ at 45 DAA for $GA_3$-treated and pollinated fruits, and 9 µmol $gFW^{-1}h^{-1}$ in non-pollinated fruits. Soluble invertase was undetectable in any treatment from 0 to 45 days, but rose sharply, averaging 57 µmol $gFW^{-1}h^{-1}$ at ripening for both $GA_3$-treated and pollinated fruits. No consistent correlation was found between ovary carbohydrate concentration and fruit growth among treatments. Differences in fruit set and size among treatments were not due to differences in enzyme activity and subsequent differences in carbohydrate accumulation.



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098

CHANGES IN RIPENING THORNLESS ERECT BLACKBERRY FRUIT

P. M. Perkins-Veazie*[1], J. R. Clark[2], and J. K. Collins[1], [1]USDA-ARS, South Central Agricultural Research Center, Lane, OK 74555; [2]Dept. Horticulture, Univ. Arkansas Fruit Substation, Clarksville, AR 72830

'Navaho' is a thornless erect tetraploid blackberry. Fruit were harvested at 6 color stages to characterize the changes occurring during ripening. Fresh and dry fruit weights indicated double sigmoidal growth while pyrene growth was single sigmoidal. Respiration was of a climacteric nature and ethylene production peaked at 0.4 nl/g-h at the dull black stage. Free ACC and ACC oxidase did not increase until the shiny black stage, corresponding with the first detectable ethylene production. Anthocyanin (cyanidin-3-glucoside) remained at low levels until fruit were 50% black (mottled). Skin and receptacle firmness decreased sharply between the mottled and black stages of ripeness. Soluble solids concentration continued to increase, and titratable acidity to decrease, into the dull black stage. These results indicate that most ripening aspects associated with edible quality occur late in 'Navaho' fruit development, but prior to stimulated ethylene production.

099

**NURSERY STOLON SERIES AND ROOTING DATE, AND SUBSEQUENT PLANT GROWTH AND DEVELOPMENT IN TWO STRAWBERRY CULTIVARS**

Kirk D. Larson, University of California South Coast REC, Irvine, CA 92718

Variations in plant vigor and productivity are often observed in annual strawberry plantings, despite the use of single-source clonal plant material. To determine the influence of stolon series and stolon rooting (set) date in the nursery on subsequent plant growth, developing stolons of two cultivars ('Chandler' and 'Selva') were tagged and set in a nursery (1013 m elevation, 41.2 N latitude) at 3-wk intervals beginning in mid-June, 1992. On 30 Sept., 1992, for each cultivar, stolons were dug and placed in one of five groups: 1) 1st and 2nd series stolons set on or before 1 July; 2) 1st and 2nd series stolons set on 21 July; 3) 3rd and 4th series stolons set on 21 July; 4) 1st and 2nd series stolons set on 14 August; and 5) 3rd and 4th series stolons set on 14 August. For each stolon group and cultivar, six plants were randomly selected for determinations of fresh wt and crown diameter, then planted in 2-L containers in growth chambers (11 hour daily photoperiod, 750 µmol $m^{-2}$ $s^{-1}$, 17/11 C). Leaf number and canopy diameter were determined at 2-wk intervals for 10 wks, after which plants were harvested for determinations of root and shoot dry wt, and leaf area. Cultivar differences were observed, but relative group rankings for most variables were fairly consistent between cultivars. For both cultivars, group 1 had the greatest, and groups 4 and 5 had the smallest initial crown diameters and stolon fresh wts. However, groups 1 and 4 had greatest final leaf area, shoot dry wts, and crown and leaf numbers, suggesting that stolon series can influence plant growth and development in strawberry.

100

COMPENSATION OF RED RASPBERRY TO PRIMARY BUD REMOVAL

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

To determine the impact of loss of primary buds on yield of red raspberry (*Rubus idaeus* L.), all primary buds on a cane were removed for two of the four canes on a hill for six Pacific Northwest raspberry cultivars at Puyallup, WA in February, 1991 and for five cultivars in February, 1992. Each cane was harvested individually and compared to non-treated canes in the same hill. Each cultivar was represented by two hills each year. In each year, there was no effect of treatment for total yield, fruit weight, length of season, or date of 5, 50 and 95 percent harvest.

101

EFFECT OF CLOPYRALID HERBICIDE ON YIELD AND FRUIT SHAPE OF 'EARLIGLOW' AND 'ALL STAR' STRAWBERRIES

Richard C. Funt, Department of Horticulture, The Ohio State University, 2001 Fyffe Ct., Columbus, OH 43210-1096

Clopyralid (Stinger) herbicide was applied at two different times and at two different rates to two June-bearing cultivars of strawberries in 1990 and 1991. The effect of clopyralid on yield, berry size and shape was recorded. The effect of clopyralid plus 2, 4-D at renovation was observed for two seasons as well. The results of this herbicide alone and in combination with other herbicides will also be discussed.

# 66 ORAL SESSION 14 (Abstr. 102–109) Collegiate Branch Forum II

102

"COMPUTER-AIDED" LANDSCAPE HORTICULTURE

Brian Fischer* and Jayne M. Zajicek
Department of Horticultural Sciences, Texas A&M University, College Station,TX 77843-2133

In designing a functional landscape, designers use visual aids to relay information and communicate with the client. Landscape horticulturists are now experiencing an age that is characterized by "computer aided". This includes plant selection, design, image processing, and presentation. As competition becomes more and more fierce in the landscape field, the firms with the best presentations will win the most clients. Techniques for assembling a professional design project with the aid of both Macintosh® and IBM® computers will be presented. This will include landscape design with MacDraft®, plant selection with PlantStax™, and perspective visualization with the New Image Design System®.

103

EFFECTS OF SURFACE DISINFECTANTS ON MICROBIAL CONTAMINATION AND ENZYME ACTIVITY IN INCUBATING WHEAT HALF-SEEDS

David H. Slaymaker, Kansas State University, Manhattan, KS 66506

The effects of three disinfectants were compared in controlling microbial contamination of incubated, de-embryonated wheat seeds (*Triticum aestivum* cv. 'Karl') and in their effects on the activity of two enzymes. Half-seeds were treated with mercuric chloride (0.02%), hydrogen peroxide (3.0%) and sodium hypochlorite (0.8%) for 10 min, rinsed with sterile, distilled water and incubated with $10^{-5}$ M GA at 26°C for 48 hr. Amylase and o-diphenolase activities were determined from half-seed extracts and the residual incubation media (RIM). Colony counts were made using an aliquot of the RIM. $HgCl_2$ was most effective in controlling microbial contamination with NaOCl doing slightly better than $H_2O_2$. The effects of surface disinfectants on half-seed enzyme activity and the significance of microbial enzyme activity will be discussed.

104

**EVALUATION OF SWEET CORN LINES FOR RESISTANCE TO NORTHERN LEAF BLIGHT AND THE *SUGARY ENHANCER* (*SE*) GENE.**

Andrea Faber, Dept. of Horticulture, University of Illinois, Urbana, IL. 61801 (John A. Juvik, Faculty Advisor).

In regions of sweet corn production in the U.S. and overseas epidemics of northern leaf blight (NLB) caused by the foliar pathogen *Exserohilum turcicum* are common. NLB can significantly decrease yields, and ear quality of susceptible and moderately susceptible sweet corn hybrids. Thirty-four BC2F7 sweet corn inbreds have been created from several crosses between field corn lines with various *Ht* resistance genes (*Ht1*, *Ht2*, *Ht3*, and *HtN*) and three high quality sweet corn inbreds homozygous for the *sugary enhancer* (*se*) gene. The*se* gene when homozygous in sweet corn kernels increases sugar content at harvest and improves fresh ear quality and consumer appeal. Seedlings of the 34 different inbreds with either the *Ht1*, *Ht2*, *Ht3*, or *HtN* gene were inoculated with race 0 and 1 of *E. turcicum*, evaluated for lesion size, amount of leaf necrosis and hypersensitivity response to compare levels of NLB resistance in different genetic backgrounds. To ascertain which of these lines also contain the *se* gene, kernels from 20 DAP (days after pollination: typical fresh harvest maturity) and mature dry ears were freeze-dried, ground into powder, extracted and quantified for sugar content using a gas chromatograph. The lines with the best resistance to NLB and containing the *se* gene have been selected for release to breeders for the development of superior sweet corn hybrids.



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POINSETTIAS GROWN IN MEDIA BLENDS OF COMPOSTED ORGANIC WASTE PRODUCTS

Andrew Keniston* and Francis R. Gouin, University of Maryland Department of Horticulture, College Park, MD 20742-5611

Rooted cuttings of poinsettia (Euphorbia pulcherrima) were grown in Sunshine Mix and 12 blended media containing various proportions of: a) composted yard waste; b) co-compost (sewage sludge composted with municipal solid waste); c) peatmoss; d) perlite; e) pine bark. Amount of composted waste products per blend varied from 50% to 78% by volume. Three fertilizer regimes: 1) O; 2) Osmocote 18/6/12; 3) Osmocote 39/0/0. Osmocote was applied after potting to render equal amounts N. Sunshine Mix with 18/6/12 Osmocote produced greatest dry weight. The more successful compost blends produced 82-85% of this dry weight without Osmocote. Several compost blends achieved greater dry mass without fertilization. Plants grown in compost media blends showed little preference for Osmocote treatments. All plants grown in compost blended media exhibited marginal chlorosis and neurosis of leaves to varying degrees. Plants grown in compost blended media tended to produce greater average bract size than plant height. Leachate tests revealed poor infiltration of water in media with high proportions of co-compost.

106

ESTIMATION OF *TALAROMYCES FLAVUS* DISTRIBUTION IN ILLINOIS SOILS.

Jean M. Unkraut*, James T. Flott, and Gary J. Kling, Department of Horticulture, University of Illinois, Urbana, IL 61801.

*Talaromyces flavus* is a soil borne fungus which is antagonistic to the fungi which cause verticillium wilt. A study was conducted to determine the distribution of *Talaromyces flavus* in Illinois nursery soils and to isolate strains of *T. flavus* from widely separated geographic regions for potential biological control of *Verticillium dahliae*. The state of Illinois was divided into 10 regions and samples were taken at 0 to 15 cm depth from both cultivated nursery soils and uncultivated wooded areas in each region. *T. flavus* was isolated on a selective medium and determined after 7 to 10 days of growth. *T. flavus* was found in all the nurseries surveyed. The distribution of *T. flavus* within regions and nurseries varied but a higher percentage of samples from northern and central Illinois contained the fungus. Soils from nursery production fields were more likely to contain *T. flavus* than adjacent uncultivated woodlands.

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PINCHING TREATMENTS FOR *LAVANDULA ANGUSTIFOLIA* MILL. CV. HIDCOTE BLUE GROWN AS A POTTED PLANT

Andrea L. Tucker*, Terri W. Starman and Amy J. MacKenzie, Department of Ornamental Horticulture and Landscape Design, University of Tennessee, Knoxville, TN 37901-1071

Lavender is grown commercially for oil production, but could be grown as a flowering potted plant due to its attractive foliage, blue flowers, and distinct aroma. In our preliminary experiment, it was noted that lavender grown as a 0.4-liter potted plant had sparse, upright growth. Two experiments were conducted to optimize the appearance of lavender as a commercially viable crop. In one experiment, plants were pinched 8 or 10 weeks after sowing with either a chemical (dikegulac at 0, 780, 1560, or 3120 mg·liter$^{-1}$) or manual (apical meristem removal) pinch. It was found that chemical applications of 780 and 1560 mg·liter$^{-1}$ applied at 8 weeks improved the appearance of the plant, giving it a more rounded and compact form as compared to the control. The plants treated at 10 weeks had an abnormal appearance due to many small axillary shoots originating from the branches. Dikegulac applied at 3120 mg·liter$^{-1}$ was phytotoxic at both stages of growth. Manual pinching alone was generally ineffective in promoting an attractive growth habit. In another experiment, it was found that lavender formed an aesthetically-pleasing, rounded canopy if both manual and chemical stimuli were applied simultaneously 6 weeks after sowing. In this treatment, concentrations of 780 and 1560 mg·liter$^{-1}$ were equally effective, while 3120 was again detrimental.

108

LEAF REMOVAL INFLUENCES CANOPY STRUCTURE, BUNCH ROT AND YIELD WITH *VITIS VINIFERA* L. CVS. OPTIMA AND CABERNET FRANC.

Sue-Ann E. Staff*, Dept. of Hort. Sci., Univ. of Guelph, Guelph, Ontario, Canada, N1G 2W1 (D.C. Percival, J.A. Sullivan and K.H. Fisher, Faculty Advisors)

Leaf removal treatments were applied to *Vitis vinifera* L. cvs. Optima and Cabernet Franc in the Canadian Niagara Region in 1992. Treatments consisted of removing 0% (no leaves), 50% (every other leaf) and 100% (all leaves) from the shoot origin to the most distal cluster when berries were pea-sized. Data was collected on canopy structure, occurrence of bunch rot (*Botrytis cinerea* Pers.:Fr.), yield, must and wine quality. Application of the 50% and 100% leaf removal (LR) treatments reduced leaf layer number (LLN), percent interior leaves (PIL) and percent interior clusters (PIC) with both cultivars. The influence of LR on LLN, PIL and PIC was greatest for the 100% treatment compared to 50% and 0%. This resulted in a reduction in the severity of bunch rot with Optima and a reduction in the incidence and severity with the disease tolerant cultivar Cabernet Franc. The 50% and 100% LR reduced yield per vine by 33% and 46% respectively with Optima and by 32% and 29% respectively with Cabernet Franc. Average berry weight of the 50% and 100% treatments was significantly lower for Cabernet Franc. Within both cultivars, there was no significant effect of treatment on the number of clusters and number of berries per cluster. Significant influence of the treatments on the must and wine quality was also noted.

109

SEEDLING GERANIUM GROWTH AND FLOWERING RESPONSES TO UNICONAZOLE

Tracy L. Grindstaff*, Terri W. Starman and Teresa A. Cerny, Department of Ornamental Horticulture and Landscape Design, University of Tennessee, Knoxville, TN 37901-1071

New cultivars of seedling geraniums are bred for compact growth habit to be grown in plugs, cell packs, or 0.4-liter pots. Chlormequat chloride (CCC) is recommended for use on these cultivars grown in 0.4-liter pots to increase the branching and green color of leaves. The objective was to determine concentration of uniconazole (UNI) foliar spray and medium drench and to compare the efficacy of UNI with CCC at 750 mg·liter$^{-1}$ on *Pelargonium* X *hortorum* cvs. Red Elite (RE) and Multibloom Scarlet (MS). Growth retardants were applied 5 weeks after sowing when plants had five leaves 2.5 cm in diameter. Three plant size variables (height, width, and peduncle length) and 3 flowering variables (flower diameter, days to flower, and bud number) were measured. The experiment showed that CCC reduced all size variables in RE and MS compared to the controls. UNI drenches at applications of 0.05 and 0.025 mg a.i./pot controlled size variables similar to CCC drenches in RE. In MS, all UNI drenches decreased plant size variables more than CCC with one exception. UNI sprays did not reduce size like CCC sprays on RE. UNI spray controlled size variables of MS similar to CCC when administered at 20 mg·liter$^{-1}$. CCC reduced flower diameter more than UNI in both cultivars. In MS, UNI drench reduced days to flower compared to CCC. Both growth regulators increased bud number of MS compared to the control.

## 74 ORAL SESSION 15 (Abstr. 110–113) Fruits/Nuts: Food Science

110

FIRMNESS, STRENGTH, AND STIFFNESS OF APPLES MEASURED BY NONDESTRUCTIVE DYNAMIC METHODS.

Judith A. Abbott*, Instrumentation and Sensing Laboratory, Bldg. 303, Agric. Research Service, USDA, Beltsville, MD 20705-2350

Sonic transmission and dynamic force/deformation (F/D) tests are potential nondestructive measurements of firmness of fresh apples that could provide consumers with more uniform product and reduce losses to packers. Sonic vibrational spectra, dynamic F/D spectra, Magness-Taylor puncture (MT), and compression tests of excised tissue specimens were recorded during storage of 'Delicious' and 'Golden Delicious' apples. Sonic resonance frequencies decreased during storage and were closely related to MT firmness and to tissue strength and rigidity. Frequencies of dynamic F/D peaks were also correlated with MT firmness but not as highly as were sonic resonance frequencies.



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DIETARY FIBER IN APPLE

Ferdous Ghevas*, Sylvia M. Blankenship, and Eric Young, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609.

Fiber composition of seven varieties of apple ; Red Delicious, Golden Delicious, Granny Smith, McIntosh, Stayman, Red Rome, and York were studied. Hydrolyzates of fiber fractions from fruit samples of these varieties were analyzed for rhamnose, fucose, arabinose, xylose, mannose, galactose, and glucose content. Fiber composition of Red Delicious and Golden Delicious apples at different developmental stages were also studied. Fruit were analyzed every 15 days starting from 30 days after fruit set through maturity. Marked varietal difference was observed in the rhamnose, fucose, galactose,and mannose content of apple fiber. The difference in arabinose, xylose, and glucose content was less prominent except for York apples which were found to have markedly lower xylose content than other varieties and McIntosh with lower glucose content than other varieties. Both Red and Golden Delicious apple fiber showed gradual increase in xylose and glucose content during fruit development. Other component sugars were also found to change during development.

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OIL CONTENT, FATTY ACID COMPOSITION, AND VITAMIN E CONCENTRATION OF 17 HAZELNUT VARIETIES, COMPARED TO OTHER TYPES OF NUTS AND OIL SEEDS.

Kais S. Ebrahem*, D. G. Richardson, R. M. Tetley, and S. A. Mehlenbacher.
Horticulture Dept., Oregon State University
Corvallis, Oregon, USA 97331

Oil content, fatty acid and vitamin E composition of seventeen varieties of hazelnuts, thirteen types of nuts, and seven different oil seeds were determined as part of a larger study on Hazelnut kernel quality. Alpha-tocopherol was the predominant (90%) tocopherol in all hazelnut varieties. In other nuts α- and Γ-tocopherols were predominant. Delta-tocopherol was found in some kinds of nuts but it was not found in hazelnuts. All four kinds of tocopherols were found in oil seeds and tocotrienols were found in some. Hazelnuts are a rich source of α-tocopherol. Oil concentration varied among hazelnut cultivars and ranged from a low of 57.9% in Hall's Giant to 67% in Tombul. Macadamias were the highest in oil content (76.9%). Oleic acid and linoleic acid comprised more than 90% of the fatty acid composition in most nuts.

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CANNING PROPERTIES OF NINE LOQUAT VARIETIES

Xing-Qian YE, Department of Food Science and Technology, Zhejiang Agricultural University, Hangzhou, Zhejiang, 310029, The People's Republic of China

The canning properties of 9 loquat (*Eriobotrya japonica* Lindl.) were investigated. The chemical components of fresh and canned fruit analyzed. The changes of these chemical components during and their effects on canning are discussed. Cultivars 'Glory,' 'For Treasure,' and 'Big Red Gown' are found most suitable for canning with their yellow to orange flesh color, good flavor and texture. 'Small Red Flower,' a small fruit cultivar, and 'White Flower,' a milk color cultivar, did not seem very good for direct canning, but they did not seem bad for producing canned fruit cocktails. There were no correlation between the chemical components, including titrable acidity, total soluble solids, sugar, total phenols, activity of polyphendoxidase, pectin, and the sensory scores of the canned loquat.

## 75 ORAL SESSION 16 (Abstr. 114–121) Fruits/Nuts: Culture and Management I

114

**OPTIMIZING SUNLIGHT INTERCEPTION IN PECAN ORCHARDS**

Bruce W. Wood*, Jeffrey W. Burcaw, Michael W.Poole, and Mark T. Burnette, USDA/ARS Southeastern Fruit and Tree Nut Research Laboratory, Byron GA 31008

The relative intolerance of pecan trees to low light environments suggests a need for the development of sunlight management strategies that optimize orchard productivity. Current strategies exhibit little emphasis on integrating sunlight interception, tree growth, and orchard design within this context. Therefore, there is a myriad of geometrical variation among commercial orchards and an associated difference in productivity.

We have developed a mathematical model incorporating computer simulations of pecan tree growth in a wide variety of orchard situations. Variables include tree shape, intertree spacings, geometrical pattern within the orchard, geographical coordinates, and time and day of year. This model predicts the extent of shading during the daily interval of maximum photosynthesis for any combination of these variables. It can also be used by the orchardist to establish orchards in which trees receive maximum levels of sunlight within specific windows of time; for example, during the period of nut filling or during the accumulation of dormant season assimilate reserves.

115

DEFICIT IRRIGATION AND SUMMER PRUNING INTEGRATED FOR HIGH-DENSITY SWEET CHERRY ORCHARDS

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

A 2-ac block of 'Bing'/Colt, Mahaleb or GM61/1 was planted 8 x 15', Feb 1991 so that 7 treatments were arranged in 6 blocks. We imposed water stress during 2 distinct periods, June or July in 1992. Once trees had stopped growing water was added (estimated @ 50% ETc) to maintain leaf turgor, but not to initiate further shoot growth. Well-watered (100% ETc) trees were summer pruned to check growth. Water stress was monitored by measuring water potential of basal bagged leaves with a pressure chamber at midday. Shoot growth was stopped by water stress. Shoot growth ceased at a trunk water potential of approximately -17 bars in both Colt and Mahaleb rootstocks although Colt rootstock went into stress more rapidly than Mahaleb. Colt may be more sensitive to water deprivation at this site than Mahaleb rootstock. Well-watered GM 61/1 trees had tree sizes much like those of water stressed Colt trees. A combination of early season stress and summer pruning (heading) may be the best combination used to control growth. Flower bud formation was noticed by season's end in these 2nd leaf trees. Water stress can be used to control tree growth, save water and encourage fruitfulness when integrated into an appropriate orchard system.

116

LOW INPUT PEACH PRODUCTION: FIRST-YEAR RESULTS

Mark A. Hubbard*, J.A. Flore, E. Hansen, W. Shane, J. Johnson, J. Wise, M. Whalon, G. Bird, and A. Jones. Departments of Horticulture, Botany and Plant Pathology, and Entomology, Michigan State University, East Lansing, MI 48824–1325, USA

Three systems of peach production have been established (Flore, *et al.*, 1991, HortScience 26(6):747) utilizing three levels of chemical input: conventional input, moderate level, and low level. The moderate and low levels of chemical input use increasing degrees of IPM. In 1992, data were collected on yield, insect and disease impact on fruit quality, vegetative growth, nitrate and simazine levels in the soil, and insecticide residues in the fruit. The yield per tree was substantially higher in the conventional treatment but this effect could be attributed to an early spring frost, local topography, or the treatment system. The percentage of fruit free from insect and disease damage was highest in the conventional treatment (95.1%), but the low input had a relatively high percentage of fruit free of damage (79.6%). Shoot cold hardiness of one year old shoots was not affected by treatment. Bud survival after a spring frost was greater in the conventional orchards, but topography may have influenced this parameter. Nitrate levels 2 m in the soil and sim-azine residues in the A horizon were not affected by treatment. Lorsban®, Guthion®, and Asana® residues in fruit are currently being analyzed and will be discussed. Additional data collected in 1993 and future years will contribute more information on the use of the low and moderate chemical input treatments on peach production.

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THINNING DATES INFLUENCE SIZE OF 'ROYAL GALA' APPLES

Robert E. Call* and Michael W. Kilby, University of Arizona, Cooperative Extension, 450 South Haskell, Willcox, AZ 85643

A thinning-timing study of apple, (*Malus domestica* Borkh. cv. 'Royal Gala'), grown on M7a rootstock, was initiated during the Spring of 1992 to determine the optimum and last effective thinning date to affect 'Royal Gala' apple size. Trees planted in 1987 in sandy-loam soil and trained on a three tier Ebro trellis system were used in this study. Thinning-timing treatments were begun at full bloom and continued weekly for four weeks making a total of five thinning dates and an non-thinned control. Each treatment's flowers and/or fruits were hand thinned to 15 - 20 centimeters between fruit



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on tree limbs. Measurements of the diameter of marked apples from each treatment were made weekly during the growing season to plot growth curves. Results show a significant difference of larger fruit size and weight of second and third thinning treatment dates as compared to the other treatment dates and the control.

118

N AND P APPLICATION METHODS AND TIMING EFFECTS ON APPLE ESTABLISHMENT: FERTIGATION VS TOP-DRESSING

Ken Kupperman* and Curt R. Rom, Department of Horticulture and Forestry, University of Arkansas, 72701

Six fertilizer regimes applied to newly planted 'Smoothee Golden Delicious' and 'Jonee' on M.26 EMLA were evaluated during two years of establishment. Treatments were: 1) control (no fertilizer applied), 2) spring top-dress (granular), 3) fall top-dress (granular), 4) split top-dress (granular) spring 50%/fall 50%, 5) spring fertigation, and 6) fall fertigation. All fertilizer treatments received 10g P/tree each season with triple super phosphate used for top-dress form and ammonium polyphosphate with fertigation. Ammonium nitrate was the N source for all treatments applied at a rate of 50g N/tree/year of tree age and adjusted accordingly for trees fertigated with APP. In the second year, 'Jonee'-control trees had significantly more bloom than other treatments; with 'Smoothee'-spring fertigated trees having more bloom than other treatments. Set, in second year however, was greater for both cultivars with spring fertigation. Trunk cross sectional area of both cultivars at the end of two seasons was significantly smaller under spring fertigation. Both fertigation treatments significantly decreased soil pH over two seasons with an associated increase in foliar Mn occurring.

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**TREE PERFORMANCE, FRUIT QUALITY, AND MINERAL NUTRITION OF 'DELICIOUS' APPLE STRAINS.**

Esmaeil Fallahi*, B.R. Simons, J.K. Fellman, M.A. Longstroth and W.M. Colt, Dept. PSES, Parma R & E Center, University of Idaho, 29603 U of I Lane, Parma, ID 83660.

Tree performance and fruit quality at harvest and after storage and leaf mineral nutrition in 28 strains of 'Delicious' apple were studied over several years. 'Classic Red', 'Hi-Early', Nured Royal', 'Rose Red', and 'Sharp Red' had bigger trunk cross sectional area (TCSA), while 'Starking', 'August Red', and 'Apex' had both bigger TCSA and cumulative yields. 'Red King Oregon Spur' and 'Improved Ryan Spur' had a high yield efficiency. 'Aomori', 'Atwood', 'Redchief', and 'Hardispur' had low cumulative yields and yield efficiencies. 'Rose Red', 'Red King Oregon Spur', 'Ace', 'Imperial', 'Starking', and 'Wellspur' had heavier fruit, while 'August Red', 'Hardispur' and 'Starkrimson' had smaller fruit than most other strains. 'Starkspur Supreme' had the highest L/D ratio and 'Early Red One' and 'Rose Red' had higher red color than those of all other strains. 'Aomori', 'Hardispur', 'Nured Royal', 'Silverspur' and 'Starkrimson' had high soluble solids concentrations. Differences were observed in the leaf mineral concentrations between different strains. 'Apex', 'Classic Red' and 'Silverspur' had a high overall acceptability, while 'Sturdeespur', 'Hardispur' and 'Aomori' were not acceptable.

120

ROOTSTOCK EFFECTS ON NORTHERN SPY APPLE LEAF COMPOSITION

Warren C. Stiles* and James N. Cummins, Department of Fruit and Vegetable Science, Cornell University, Ithaca, NY 14853

Leaf samples collected during the 1988-90 seasons were analyzed to evaluate influence of selected rootstock clones on the composition of Northern Spy apple leaves. Rootstocks included 17 elite selections from the Geneva breeding program plus M.9, M.26, M.7, MM.106 and MM.111 as references. Rootstock selections were grouped according to relative vigor and compared with appropriate references. Significant rootstock effects were more frequent in the two smaller tree-size groups. Each of the 10 elements analyzed exhibited significant rootstock effects in two or more vigor groups. No rootstock selection consistently resulted in higher or lower concentrations of all elements when compared with the reference rootstock of similar vigor.

121

**TRAINING AND ROOTSTOCK STUDIES WITH PEAR CULTIVARS ON QUINCE SIZE-CONTROLLING CLONES.**

G. Tehrani* and W. Lay, Horticultural Research Institute of Ontario, Vineland Station, Ontario, Canada L0R 2E0

In 1987, a study consisting of 3 training systems (TS) [Supported modified leader (S), Free Palmette (P) and Mini-Tatura (MT)] with Anjou (A), Bartlett (B) and Flemish Beauty (FB) on Quince A & C and Provonce C134, in a high and ultra-density planting, was initiated on a fine sandy loam soil. Blossoms were counted and removed during 1988 to 1990 seasons. Palmette TS increased bloom efficiency (BE) but did not affect the number of florets/cluster. Quince C produced higher BE than either QA or C134. Bartlett had the highest BE followed by A & FB. Anjou exhibited more florets/cluster than either B or FB. Rootstock or TS did not influence this variable.

Irrespective of rootstock and training, the largest trees were FB followed by A & B. Quince C produced trees smaller than QA & C134. Mini-Tatura reduced tree size significantly compared to S & P. The cumulative yield for 1991 & 92 (5th and 6th leaves) was 85 tonnes/ha for MT compared to 35 & 37 for S and P respectively. Quince clones had no effect on yield, but A was significantly less productive than B or FB. Cultivar, rootstock or training did not affect mean fruit weight during 1992. Bartlett had higher number of pears/tree compared to A & FB. Palmette training system produced more pears per tree in comparison to S and MT.

## 76 ORAL SESSION 17 (Abstr. 122–128)
## Cross-commodity: Recycling

122

THE FATE OF N FROM COMPOSTED POULTRY MANURE WHEN APPLIED TO FORSYTHIA AND CHRYSANTHEMUM

Gerald Klingaman* and G. L. Wheeler, Department of Horticulture and Forestry, University of Arkansas, Fayetteville, AR 72701

'Lynwood Gold' forsythia and 'Jessica' chrysanthemum were grown for 12 weeks in a nursery mix consisting of 5 parts composted pine bark, 1 part composted hardwood bark and 1 part sand. Fertilization was by topdress applications of composted poultry manure at rates of 1, 2 and 3 g N per container, resin coated slow release fertilizer at 3 g N per container, or with constant liquid fertilization at 200 mg N per liter. Leachate samples were collected weekly and nitrate, nitrite, ammonium and total nitrogen determined. At 12 weeks, plant dry weight and the amount of nitrogen in the plant, media and leachate determined. Total nitrogen loss in the leachate for the compost was rapid during the first three weeks and then fell to low levels. The resin coated fertilizer released a higher and constant nitrogen flux during the study than the composted manure but total nitrogen loss over the 12 week period was lower than for compost. The leachate nitrogen in the constant liquid fertilization treatment increased during the study. The relative proportion of nitrogen in the medium, compost and leachate will be discussed.

123

**SEWAGE SLUDGE COMPOST'S CUMULATIVE EFFECTS ON CROP GROWTH AND SOIL PROPERTIES**

Robert F. Bevacqua*, South Coast Research & Extension Center, University of California, 7601 Irvine Blvd., Irvine, CA 92718.
Valerie J. Mellano, Cooperative Extension, University of California, San Diego County, 5555 Overland Ave., Bldg. 4, San Diego, CA 92123.

Onion (Allium cepa cv. Spanish Sweet Utah), lettuce(Lactuca sativa cv. Black Seeded Simpson), snapdragon (Antirrhinum majus cv. Sonnet Yellow), and turf (Festuca arundinacea cv. Marathon) were grown twice annually (spring and fall) on a San Emigdio sandy loam (course-loamy, mixed calcareous thermic, Typic Xerorthents) soil for two years that was treated with a cumulative total of 0, 37 and 74 MT/ha of sewage sludge compost from San Diego. The soil received two compost treatments each year and crops were planted within a week of compost incorporation. Crop growth was monitored and the results of the fourth or final planting will be presented. Seedlings of onion, snapdragon and lettuce transplanted to compost treated plots displayed more vigorous establishment than those in the control plots. Compost treatments produced higher yields of onion, turf and lettuce. Snapdragon yield was not affected by compost treatment. Significant changes in pH, OM, EC, and various nutrients were noted upon the analysis of the soil.



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GROUND KENAF STEM CORE CAN BE USED SUCCESSFULLY AS A CONTAINER MEDIUM AMENDMENT

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

The woody stem core of kenaf (*Hibiscus cannabinus* L.) was ground and used without composting as a container medium amendment for the production of several tropical foliage and nursery species. Media made of various proportions of kenaf and peat moss were amended with micronutrients, gypsum, dolomitic lime stone powder, superphosphate, Osmocote, a wetting agent and a fungicide. Plant growth in these media was compared to that in two widely used commercial media. *Brassaia actinophylla* in kenaf amended media grew taller and had more leaves, heavier weight, and better root grade than those produced in the two commercial media. *Pittosporum tobira* plants in kenaf media were taller, wider, and heavier than those grown in the commercial media. Other species tested also responded favorably to media amended with kenaf. Media containing the ground kenaf core tended to maintain the optimum pH better and their leachate samples had lower electrical conductivities than the commercial media. Shrinkage was a problem when 100% fine ground kenaf was used, but this was greatly reduced by adding peat moss or using a coarser grind. Media containing kenaf required more frequent watering than did the commercial media.

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DISPOSAL METHODS FOR VEGETATIVE WASTES FROM HURRICANE ANDREW.

D. Ulmer[1], W. Townshend[1] and H. Bryan*[2], [1]USDA, SCS and SDSWCD, 28801 SW 157 Ave., Homestead, FL 33031; [2] Univ. of Florida, IFAS, TREC, 18905 SW 280 St., Homestead, FL 33031.

Hurricane Andrew created over 17 yrs. of wood debris in a few hrs. in Dade County on 8-24-92. The rush to burn debris contributed to respiratory health problems. Through meetings with FEMA, Army Corps of Engineers, Dade County and environmental groups, SCS and SDSWCD pushed the idea of recycling this waste. Mulching and eventual composting of wood debris and using farmland as reuse sites were promoted. A joint pilot project established a team of mobile chippers coordinated by representatives of each agency. FEMA funded the project and chippers began working in groves after trees were trimmed and branches were stacked in tree rows. Over 600 ha. were chipped and mulched during the 10 wk. contract period. More than 800 ha. are to be done under a new contract. Mulched material from other sites were delivered free to landowners who covered exposed roots of trees and replaced soil blown away by high winds. Over 200,000 $m^3$ of mulch were delivered 5 mos. after the hurricane and 1.2 million $m^3$ more were requested. For final pickup of debris, central grinding sites were established and mulch was hauled to growers for mulch or compost.

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EFFECT OF AMENDING SOIL WITH MUNICIPAL SOLID WASTE (MSW) COMPOST ON YIELD OF BELL PEPPER AND EGGPLANT

Monica Ozores-Hampton* and Herbert H Bryan, IFAS, Tropical Research and Education Center, HOMESTEAD FL 33031

At two locations MSW was incorporated into the soil at 0, 90, 134 t/ha. Bell pepper and eggplant were transplanted into the field. Total marketable and large size fruit yield of eggplant were significantly higher in the MSW compost treatments than in the control. There were no significant differences in the mean size of marketable and large size eggplant fruit. Total marketable bell pepper yield tended to be higher in the MSW compost treatments than the control, but differences were not significant. MSW compost treatments resulted in significantly higher large pepper yield than the control, but mean fruit size was not affected by MSW.. In general plants with MSW compost yielded higher than the control.

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BROILER AND LAYER POULTRY MANURE AS FERTILIZERS FOR LETTUCE, CABBAGE, AND STRAWBERRY

I.G. Rubeiz*, M.T. Farran, A.S. Sabra and I.A. Al-Assir, American University of Beirut, FAFS, Beirut, Lebanon

Floor litter from broiler chickens (BCM), 8 weeks old, and from laying hens (LHM), 1 year old, were evaluated as nitrogen fertilizers. Lettuce cv. Paris Island cos was transplanted to a greenhouse that had received 6 months earlier 18t/ha BCM (19% $H_2O$, 5.5% N), 28t/ha LHM (22% $H_2O$, 3.7%N), or $NH_4NO_3$ at 100kg N/ha during the season. Yields were comparable among all treatments. Cabbage cv. Cosmos Royal was grown under 2.4 or 4.8t/ha BCM (2.3% $H_2O$, 4.5% N, 2.2% P), 3 or 6t/ha LHM (3.4% $H_2O$, 3.8% N, 3.4% P), or $(NH_4)_2SO_4$ at 100kg N/ha. Comparable yields were achieved among all treatments. Strawberry cv. Douglas was grown under 11t/ha BCM (7.7% $H_2O$, 4.9% N, 1.6% P), 13t/ha LHM (5.6% $H_2O$, 3.9% N, 1.7% P) or $(NH_4)_2SO_4$ at 100kg N/ha. Highest yields, over a 3 month-period, were under BCM followed by LHM, $(NH_4)_2SO_4$ and the control. Poultry manure is equally effective to mineral N fertilizers on head forming crops, and superior to mineral N on long season strawberry. BCM is recommended over LHM when both are available.

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RELEASE OF NITRATE - N FROM TROPICAL SOILS TREATED WITH FERTILIZERS

Mark D. Hamilton*, Frank J. Cruz, and James McConnell, College of Agriculture and Life Sciences, University of Guam, UOG Station, Mangilao, Guam 96923.

The passage of nitrate nitrogen through three Guam soils was investigated using six different fertilizers. Controlled release and water soluble forms were applied to soils in polycarbonate pots 11cm in diameter. Controls received no fertilizer application. Soil types used were Yigo silty clay and Guam cobbly clay loam, from northern Guam, and Akina silty clay from southern Guam. All pots were exposed to ambient temperature and humidity but were shielded from direct sunlight and rain. All were kept near field capacity by daily applications of distilled water. Leachate was collected weekly for three months and measured using an ion selective electrode. Initial results suggest that nitrate levels were primarily affected by soil type rather than the type of fertilizer applied. Nitrate was invariably highest in Yigo silty clay, lowest in the Akina silty clay and intermediate in the Guam cobbly clay pots. Patterns of nitrate release were similar in the Yigo silty clay and Guam cobbly clay soils with peak values at the fourth and fifth week, 700ppm and 450 ppm respectively, then falling to 300ppm and 150ppm respectively by the sixth week. However, Akina silty clay soils gradually increased in nitrate to 120 ppm in the last two weeks of the experiment.

## 77 ORAL SESSION 18 (Abstr. 129–136) Vegetable Crops: Breeding and Genetics II

129

DISCOVERY OF UNREDUCED 2N POLLEN IN DIPLOID AND TETRAPLOID IPOMOEA RELATIVES OF SWEETPOTATO.

Janice R. Bohac, US Vegetable Lab, ARS,USDA, Charleston, SC 29414

In many crop species, unreduced 2n pollen has facilitated crossing wild species of a lower ploidy number to the polyploid crop species. Previous work in this laboratory identified high levels of 2n pollen in 4X *Ipomoea batatas* and low levels of 2n pollen in 6X (sweetpotato). The closest related species to sweetpotato are classed as the group Batatas of *Ipomoea*, and are a potential source of resistance genes. Before the 2X and 4X species can be used to improve 6X sweetpotato, the ploidy gap must be bridged. Several *Ipomoea* species were examined for 2n pollen to enable the 2X and 4X species to be crossed to sweetpotato. A minimum of three accessions per species were examined and regular and 2n pollen counted for a minimum of three flowers per plant. Six of the seven species in group Batatas and the other two species examined had high levels of 2n pollen, many over 50%. The 2n pollen trait appears to be very common in the *Ipomoea* genus and is proposed to play an important role in the evolution of the species. The common occurrence of very high levels of 2n pollen in all of the species examined indicated the feasibility of using these species in sweetpotato improvement despite ploidy differences.



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BRIDGE SPECIES FOR INTROGRESSION OF WILD GERMPLASM IN SWEET POTATO BREEDING.
Orjeda Gisella*; Carey E. and Lawrence M., International Potato Center, P.O. Box 5969, Lima 1 Peru.

The species of section Batatas represent the primary potential source of wild germplasm for sweet potato breeding. Their wide distribution and adaptation make their use desirable, but their direct use is constrained by their ploidy level (2x, and 4x, in contrast with cultivated I. batatas which is 6x) and lack of storage root production.

We investigated 4x clones of interspecific origin (6x I. batatas x 2x I. trifida) as bridges to introgress genes from several wild species of the section Batatas to I. batatas. Six 2x wild species from different origins were reciprocally crossed to the 4x clones. The crosses were successful only when the diploid wild species were used as females (2x x 4x) indicating unilateral interspecific incompatibility. The unsuccessful types of crosses (4x x 2x) were repeated using wild hybrid males containing I.trifida in their parentage. This time only those crosses involving a hybrid having I. trifida as its female parent produced seeds. Progenies from the successful 2x x 4x crosses were diploid instead of the expected triploid. Triploid progenies were obtained only in the 4x x (2x hybrid) crosses. Some triploid progenies produced 2n pollen in varying frequencies. These results show different levels of crossing barriers among Ipomoea species and give us alternative pathways for overcoming them. I. trifida was identified as a possible bridge species.

131
SELECTION FOR RESISTANCE TO SWEETPOTATO WEEVIL
Paul G. Thompson*, John C. Schneider and Boyett Graves, Mississippi State University, PO Box T, Mississippi State, MS 39762

Narrow-sense heritability and selection response estimates for weevil resistance were higher based on half-sib family means than on individual plants. Resistance levels in available sources are low and evaluation with low weevil numbers is essential for differentiation. Consequently, highest performing families produce multiple plants with no injured roots and separation of resistance levels among those plants is impossible. Since a large amount of additive variance is contained among plants within families and early reduction of plant numbers would increase breeding efficiency, a study was conducted to determine the effectiveness of individual plant selection in combination with half-sib families. Two plants were selected from each of the 10 highest families based on weevil resistance and yield. Selected clones were compared for resistance levels to means of their families when tested over 2 years. Fifty percent of selected clones had higher resistance levels than their family means indicating that individual plant selection was effective. Optimum methods of combining family and individual plant selection will be discussed.

132
VARIATION IN YIELD AND RAPD MARKERS AMONG IPOMOEA BATATAS cv. JEWEL CLONES
Arthur Q. Villordon* and Don R. LaBonte, Dept. of Horticulture, LSU Agricultural Center, Baton Rouge, LA 70803

Sweetpotato clonal propagation is achieved through sprouts obtained from roots saved from the previous crop. Recommended cultural practices dictate replacing seedstock with foundation seed on a continual basis to maintain the original attributes of the variety. Theoretically, cultivar purity is maintained within and among foundation programs. However, mutations are common in sweetpotato and not all of these off-types may be detected through visual selection. The existence of genetic variation in quantifiable traits, i.e., yield, among foundation stocks may indicate that current maintenance practices need to be improved.

Yield tests and RAPD analysis were conducted among Jewel clones obtained from eight sources. Significant differences in yield among clones were observed during the 1992 season. The yield tests were conducted in two locations in Louisiana. Concomitantly, genomic DNA was isolated from each clone using a modified cTAB procedure and assayed against twenty primers. Eight primers which produced distinct, reproducible bands were identified and used for polymorphism analysis. At least one primer (OPA-06) demonstrated putative RAPD marker variation. Two-primer assays also revealed differences in RAPD markers. The results indicate the potential usefulness of RAPD markers in sweetpotato breeding, particularly in cultivar maintenance.

133
MAPPING QUANTITATIVE TRAIT LOCI OF TUBER TRAITS IN DIPLOID POTATO (*Solanum ssp.*)
Rosanna Freyre* and Dave Douches, Dept. Crop and Soil Sciences, Michigan State University, E. Lansing MI 48824.

Isozymes, RFLPs and RAPDs were utilized for Quantitative Trait Loci (QTL) analysis in diploid potato. The tuber traits under study were specific gravity and tuber dormancy. The two populations used, TRP132 (127 individuals) and TRP133 (110 individuals) have a common maternal parent and combine genomes of *Solanum tuberosum* (haploid), *S. chacoense*, and *S. phureja*. Specific gravity data was obtained from two seasons' field trials: 2 locations with 3 replications in 1990, and 1 location with 2 replications in 1991. The length of dormancy was evaluated in 1990. Both populations were characterized with 11 isozyme loci. Further studies focused on TRP133, characterizing it with 45 RFLP loci and over 60 RAPD loci. Statistical analyses were conducted to identify significant associations between markers and quantitative trait variation, epistatic interactions between markers, and their overall effect on the phenotypic variation for the traits. Significant QTLs have been localized on the potato genome through the use of molecular maps.

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IMMUNITY TO INFECTION BY POTATO VIRUS Y AND POTATO VIRUS X IN A *Solanum phureja - S. stentomum* HYBRID POTATO POPULATION
Roger L. Vallejo*, Wanda W. Collins, J.B. Young and Rocco D. Schiavone

A random sample of 6000 individuals from a recombinant *Solanum phureja - S. stentomum* hybrid population and 250 individuals of *Solanum phureja* were twice inoculated with potato virus Y (PVY) strain "o" using the air brush technique. Symptomless seedlings were field transplanted for further evaluation and 1508 seedlings were judged to be resistant to PVY (33%). At harvest, a mild selection pressure for tuber appearance was applied and 602 clones were selected.

Selected clones were re-evaluated for PVY resistance in the greenhouse: twice inoculated with PVY, tested by ELISA (Enzyme-linked immunosorbent assay), graft-inoculated with tobacco PVY infected scions, and subjected to a second ELISA test. To assess immunity to infection by PVY, the ELISA negative clones were bioassayed using tobacco cv. "Burley 21" as a plant indicator. We identified 224 PVY immune clones (4.8%).

Simultaneously, the first year PVY selected clones were twice inoculated with U.S. common strain of potato virus X (PVX). Clones free of PVX symptoms were tested by ELISA. Negative clones were re-inoculated with PVX and symptomless clones were re-tested by ELISA. To assess immunity to infection by PVX, negative clones were bioassayed using *Gomphrena globosa* as a plant indicator. We identified 7 immune (1.3%); 4 highly resistant and 4 resistant clones. Eight clones showed high levels of resistance to both PVY and PVX (high resistance to immunity).

135
EVALUATION OF YELLOW-FLESH POTATO CLONES
Kathleen G. Haynes* and Stephen L. Sinden, USDA/ARS, Vegetable Laboratory, Beltsville, MD 20705

For the yellow-flesh fresh market, potato clones with intense yellow-flesh and uniform size are desired. Twenty-five yellow-flesh clones were evaluated for individual tuber weight and tuber yellowness as measured by a reflectance colorimeter in replicated field trials in Presque Isle, Maine, in 1991. There were significant differences among clones for yellowness. Cluster analysis was used to group the clones by mean tuber weight in grams (MTWT) and variance of the mean tuber weight (VMTWT). Four clusters were identified. 'Yukon Gold' was in a cluster by itself: MTWT=90 and VMTWT=86. Four clones formed a second cluster. The averages of these four clones were: MTWT=33 and VMTWT=3. MTWT was too small in the second cluster for these four clones to warrant further evaluation. Three clones formed a third cluster. The averages of these three clones were: MTWT=78 and VMTWT=43. The remaining 17 clones formed the fourth cluster. The averages of these 17 clones were: MTWT=54 and VMTWT=11. The more intense yellow-flesh clones in the third or fourth clusters should undergo further evaluation for their fresh market potential.

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APPLICATION OF DIBA TO DETECT TMV AND CMV IN PEPPER PLANTS
Liu Yong , Vegetable Research Institute of Hunan Agricultural Sciences, Changsha410125,China
Dot Immunobinding Assay(DIBA) is a very specific method in the detection of TMV and CMV in pepper plants. There is no positive reaction in the detection of CMV with TMV--Antiserum and of TMV with CMV--Antiserum respectively. The maximum reacting dilutions of crude sap of TMV and CMV are 5120 and 2560, respectively. The comparison of three blocking systems in TMV and CMV detection showed that both TBST+3%BSA and TBST+3%Casein systems are better than TBST system. The sensitivity of detection of sap extracts of infected pepper leaves with TMV or CMV by DIBA is more than that of by Immuno Sorbant Election Microscopy.

# 78 ORAL SESSION 19 (Abstr. 137–144) Woody Ornamentals: Growth and Development

137
PLANT GROWTH REGULATORS IN THE FORCING SOLUTION INFLUENCE PROTEIN EXPRESSION OF FORCED SOFTWOOD GROWTH
Guochen Yang* and Paul E. Read, Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724

Plant growth regulators (PGR) in the forcing solution have been demonstrated to influence the bud break and shoot elongation for a wide range of woody plant species (Yang and Read, 1989). However, it was not clear how PGR in the forcing solution modified the breaking of bud dormancy at the molecular level, in terms of protein expression. Dormant stems of spirea and privet were forced in forcing solution containing 200 mg 8-hydroxyquinoline citrate per liter and 2% sucrose, plus different concentrations of BA, IBA or $GA_3$. New softwood growth was harvested for protein analysis. The preliminary results suggest that total protein expression was stimulated by adding BA or $GA_3$ to the forcing solution for spirea and privet. The protein expression was not well correlated with the concentration of IBA in the forcing solution. However, a slight increase of total protein expression was noticed when a higher concentration of IBA was added to the forcing solution for privet. Results of this research will be discussed in relation to development of a better understanding of the physiology of bud dormancy.

138
PRE-FORCING ETHANOL TREATMENTS INFLUENCE BUD BREAK AND SHOOT ELONGATION OF FORCED WOODY PLANT SPECIES
Guochen Yang and Paul E. Read*, Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724

Ethanol has been used as a disinfestation agent for *in vitro* studies and micropropagation purposes. A previous study indicated that ethanol may have effects similar to those of bleach solution on bud break of woody species (Yang and Read, 1992). Research was therefore conducted to determine ethanol effects on the breaking of bud dormancy. The basal one third of dormant lilac, privet and spirea stems was soaked in different concentrations of ethanol solution (0, 25, 50, 75 or 95%) for 15 minutes before placement in the forcing solution. The results demonstrated that the pre-forcing ethanol treatments hastened bud break for lilac and privet while delaying bud break for spirea. The percentage of bud break and shoot elongation for lilac and privet were also promoted. Generally speaking, 75% ethanol was the best treatment. Quality softwood growth was therefore produced in the off-season. Such new growth can then be used either as explant materials for micropropagation or as cuttings for rooting.

139
EFFECT OF ROOTSTOCK SHOOTS ON GROWTH OF CONTAINERIZED CITRUS NURSERY TREES
Jeffrey G. Williamson*, Brian E. Maust and Ali Al-Jaleel, Horticultural Sciences Department, University of Florida, Gainesville, FL 32611

Two experiments were conducted with Swingle citrumelo [*Citrus paradisi* (L.) Osb. x *Poncirus trifoliata* (L.) Raf.] and Cleopatra mandarin (*C. reticulata* Blanco) seedlings budded with 'Hamlin' orange [*C. sinensis* (L.) Osb.] to determine the effects of rootstock shoots on nursery tree growth. All experiments were conducted in a greenhouse. Plants were forced by cutting off the rootstock above the bud union (C), or by bending the rootstock shoot above the bud union and tying it to the base of the plant (B). In one experiment, rootstock leaves for B plants were subjected to 4 levels of shade: (1) no shade; (2) 70% shade; (3) 90% shade; or 95% shade. In another experiment, rootstock shoots of B plants were subjected to 4 levels of defoliation: (1) no defoliation; (2) approximately 33% defoliation; (3) approximately 66% defoliation; and (4) complete defoliation. Scion stem and leaf dry weights, leaf area and number, and shoot length were less for plants with shaded rootstock tops than for nonshaded plants. Stem and leaf dry weights and leaf area of scion flush 1 were less at 90 and 95% shade than at 70% shade. Defoliation of rootstock tops reduced scion stem and leaf dry weights, leaf area and number, and shoot length compared to nondefoliated plants. Most scion growth measurements were reduced more by complete defoliation than by partial defoliation.

140
GROWTH RESPONSES OF CHERRY ROOTSTOCK CULTURES TO VARIED CARBON DIOXIDE, SUCROSE,AND LIGHT REGIMES
Shaukat Ali, R. L. Andersen* and K. W. Mudge , Departartment of Fruit and Vegetable Science, , and Department of Floriculture and Ornamental Horticulture, Cornell University, Ithaca, NY 14853, and Department of Horticultural Sciences, N.Y.S.A.E.S., Cornell University, Geneva, NY 14456

Poor growth and high mortality of *in vitro* produced plants during acclimatization stage has troubled propagators. Studies were undertaken to improve growth and *ex-vitro* performance of 'Gi148/1,' a new *Prunus cerasus* L. x *P. canescens* Bois (cherry) rootstock cultivar. Two experiments were conducted during the course of this study. In a specially designed apparatus growth reponses of shoot cultures to two $CO_2$ levels (340ppm, 1200ppm) and five sucrose levels (0,2,5,10, and 20mg/l) were studied. Leaf area leaf dry weight, number of shoots and total plant dry weight were significantly increased with increase in sucrose concentration in the media regardless of the CO2 enrichment.

In the other experiment Stage III shoots of the same cultivar were exposed to two $CO_2$ (400-500ppm, 1200-1300ppm) and three different light levels (30-40, 60-75, and 85-100umol.$s^{-1}$.$m^{-2}$) for 45 days. Significant increases in leaf area, leaf and shoot dry weight and total plant biomass were observed with CO2 enrichment and increased illumination intensity.

141
GRAFT COMPATIBILITY AMONG CHESTNUT SPECIES (CASTANEA SPP.)
Hong Wen Huang*, J.D. Norton, G.E. Boyhan, and B.R. Abrahams, Department of Horticulture, Auburn University, AL 36849 USA

Graft incompatibility of 3 chestnut Castanea spp. was studied. Nine American chestnut C. crenata Sieb. & Zucc and 15 Chinese chestnut C. mollissima Bl. cultivars used as scions were tested on rootstocks of Chinese chestnut. Interspecific grafts with 7 of 9 American chestnut selections had satisfactory graft compatibility on Chinese chestnut rootstocks (70%-100%), so did 6 of 8 Japanese chestnuts. Twelve and 10 out of 15 Chinese cultivars had high graft compatibility on Chinese chestnut rootstocks. Three Chinese cultivars with less than 50% success were probably due to very diverse genetic variation within one cultivar group of Chinese chestnuts. Spring grafts always had higher percent success rates than fall grafts. Graft incompatibility was not found to be related to the cambial isoperoxidase banding patterns in the present study.

142
RAPID GRAFT PROPAGATION OF GRAPE ROOTSTOCKS IN TEXAS

George Ray McEachern and Bryan G. Roth Department of Horticulture Science, Texas A&M University, College Station, TX 77845-2134

Dormant adult hardwood cutting of Vitis candicans (VC) grapes were grafted, callused and grown in 1990, 91, and 92 at College Station, TX. Four indole-3-butyric acid (IBA) treatments were evaluated with all four promoting callus and root formation significantly over a no IBA control. Nine callus treatments were evaluated with Outdoor Moist Sand being significantly superior. Ten VC seedlings from throughout Texas were compared, Smith Mustang being significantly superior.



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IDENTIFICATION OF THE SOURCE AND STRUCTURE OF A FUNGISTATIC SUBSTANCE IN SPHAGNUM MOSS

Charles E. Hess, Department of Environmental Horticulture, University of California, Davis, CA 95616

Horticulturalists have used sphagnum moss as a germination medium for years. It has a high moisture holding capacity, provides good aeration, and seedlings germinated in sphagnum moss have a lower incidence of "damping off", a syndrome characterized by the rapid death of large numbers of seedlings caused by several fungi including *Pythium, Rhizoctonia,* and *Fusarium.* Substances have been extracted from sphagnum which inhibit the growth of the fungi associated with damping off. The primary source of the fungistatic substances are bacteria which grow in association with sphagnum moss. Although there are variations in the species of bacteria found in sphagnum moss collected from different geographical areas, they all appear to be in the genus *Pseudomonas.* One of the fungistatic substances has been identified as the seven carbon ring compound known as tropolone.

144

EVALUATION OF SELECTED WARM-SEASON TURFGRASS SPECIES GROWN IN RIYADH REGION, OF SAUDI ARABIA.

Fahed A. Al-Mana ,Tariq M. El-Kiey and N. Al-Khalifa, Plant Production Department, College of Agriculture, King Saud University, Saudi Arabia.

An investigation was conducted to evaluate the growth and adaptability of ten selected warm-season turfgrass species under the environmental condition of Riyadh Region, Saudi Arabia. The establishment rate, yield fresh weight and quality assessments, as evaluation parameters, showed that there were significant differences among these various turfgrass species. Adalyd seashore paspalum and Tifgreen bermudagrass showed the best adaptation, if properly managed. On the other hand, Tifway bermudagrass and Variegata St. Augustinegrass were poorly adapted. Although Egyptian crabgrass showed better growth and good quality, its use may be limited due to its low cold tolerance. Morecver, there were some observations that may limit the use of other turfgrasses, such as the cold stress effect on the common bermudagrass, the very low establishment rate of Korean velvetgrass and the vertical growth habit and low density of local bermudagrass.

## 79 ORAL SESSION 20 (Abstr. 145–152) Vegetables: Controlled Environment

145

LONG-DURATION EXPOSURE FACILITY (LDEF) OF NASA HAS LITTLE DELETERIOUS EFFECT ON CUCUMBER SEEDS

Todd C. Wehner*, Department of Horticultural Science, Box 7609, North Carolina State University, Raleigh, NC 27695-7609

Cucumber (*Cucumis sativus* L.) production during sustained space missions depends on reliable seed storage and seedling growth in a production facility aboard the space vehicle. NASA sent a space platform, the LDEF, into earth orbit aboard the shuttle Challenger in April 1984. It was retrieved by the shuttle Columbia in January 1990. Cucumber seeds were stored with several levels of protection (constituting 6 treatments) aboard LDEF. Field tests were run at Clinton, NC with 2 seasons, 4 replications, 4 harvests, and 12 seed treatments (including 6 controls). Traits measured included seedling emergence and abnomalities, vine growth, flowering and yield. The largest effects were for percentage emergence, where the seeds receiving the least protection (little cover, vented to outer space) had 40% emergence compared with 80% for the control. There were a large number of seedling abnormalities in the vented treatments, with cotyledon mutants most common, followed by true leaf, then stem. The least protected treatment had 75% abnormalities (mostly minor), compared with 30% for the control. However, plants recovered rapidly, so yield, earliness, percentage cull fruits, and disease incidence were not significantly affected by storage on LDEF.

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POTATO PRODUCTION IN NASA'S BIOMASS PRODUCTION CHAMBER WITH REFERENCE TO ATMOSPHERIC VOLATILES

R.M. Wheeler*, B.V. Peterson, C.L. Mackowiak, and G.W. Stutte, NASA Biomedical Operations (rmw) and The Bionetics Corp. (bvp, clm, gws), Kennedy Space Center, FL 32899.

Potatoes (*Solanum tuberosum* cv. Norland) were grown for 105 days in a large (20 $m^2$), closed chamber to assess their potential for life support in space. Cultural conditions included a recirculating NFT culture, 12/12 photoperiod, 16°C, 1000 $\mu$mol $mol^{-1}$ $CO_2$, and approximately 900 $\mu$mol $m^{-2}$ $s^{-1}$ PPF from HPS lamps. The chamber was separated into two halves with one atmosphere continuously passed through charcoal filters, while the other was not filtered. Plants grown in the filtered air showed a more "induced" appearance early in growth in comparison to plants in the unfiltered air (*i.e.* reduced shoot growth and early tuber bulking). Ethylene levels in the atmospheres ranged from 10 to 60 ppb in the unfiltered treatment and 10 to 40 ppb in the filtered. Mass spectral analyses indicate that the filters efficiently reduced heavier organic volatiles, but were not effective for lighter volatiles (*e.g.* ethylene). Biogenic emissions from the plants were identified, as well as components from glues and caulking compounds. Final tuber yields were similar but shoot biomass was higher and harvest index lower in the unfiltered treatment: charcoal filtered--10.1 kg $m^{-2}$ tuber FW, 1.9 kg $m^{-2}$ tuber DW, 2.5 kg $m^{-2}$ total plant DW, 76% harvest index; unfiltered--10.9 kg $m^{-2}$ tuber FW, 1.9 kg $m^{-2}$ tuber DW, 3.1 kg $m^{-2}$ total plant DW, and 61% harvest index.

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USE OF CONTINUOUS LIGHTING DURING THE RICE LIFE CYCLE TO INCREASE GRAIN YIELD FOR A CELSS

Gayle M. Volk* and Cary A. Mitchell, NASA Specialized Center of Research and Training in Bioregenerative Life Support, Purdue University, West Lafayette, IN 47907-1165.

Rice has been selected as a CELSS candidate species for human life support in space. Research optimizing environmental parameters, such as daylength, has increased overall grain yield. Rice is a short day plant, but after floral induction, it can be switched to continuous light. Greenhouse studies of Ai-nan-tsao, a high tillering japonica cultivar, have shown that edible yield rates can be increased from 6.2 g $m^{-2}$ $d^{-1}$ to 14.1 g $m^{-2}$ $d^{-1}$ if the cultivar is switched from 8-h days to continuous light after panicle emergence. If calculated on a volume basis, those yields are 8.3 g $m^{-3}$ $d^{-1}$ and 20.2 g $m^{-3}$ $d^{-1}$, respectively. Shoot harvest index was 37% for plants grown under 8 h days, but increased to 55% for plants switched to continuous light. There was a corresponding increase in non-edible biomass accumulation by the plants. Also, individual panicle weight increased from 0.54 g to 1.12 g when plants were switched to continuous light. Studies are in progress with 8-h days applied for 1 or 2 weeks during a continuously illuminated vegetative growth period. This project was supported in part by NASA grant NAGW2329.

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CHANGES IN WATER AND NUTRIENT USE EFFICIENCY DURING WHEAT GROWTH AND DEVELOPMENT.

Wade L. Berry*, Raymond M. Wheeler, Cheryl Mackowiak
UCLA, Laboratory of Biomedical and Environmental sciences, 900 Veteran Ave., Los Angeles, CA 90024-1786 (wlb), Nasa Biomedical Operations and Research Office, Mail Code MD-RES, Kennedy Space Center, FL 32899 (rmw) and Bionetics Corp., Kennedy Space Center, FL 32899 (clm)

Wheat (cv. Yecora Rojo) plants were grown in a closed chamber as part of NASA's Controlled Ecological Life Support System (CELSS) program. Plants were grown using a recirculating hydroponics with EC controlled at 0.12 S $m^{-1}$ by automatic additions of a nutrient concentrate, and pH was controlled at 5.8 units with automatic additions of nitric acid. Daily $CO_2$ exchange , water uptake, and nutrient uptake were monitored for the entire 20 $m^2$ canopy throughout growth. Nutrient use efficiency (NUE) relative to water and $CO_2$ uptake were determined, where NUE-W was defined as the amount of water taken up per unit of nutrient and NUE-C as the amount of carbon fixed per unit of nutrient. Water uptake remained relatively constant after canopy closure (25 DAP), where $CO_2$ uptake peaked during rapid vegetative growth and then declined gradually with age and gain fill. Nutrient uptake also peaked during vegetative growth but declined sharply after anthesis. Water use efficiency (WUE) was high early in growth and then declined with age due to the decrease in $CO_2$ exchange over time. In contrast, NUE-C and NUE-W were low during vegetative growth and the increased nearly 10-fold during grain fill.

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CHARACTERIZATION OF POPULATION $C0_2$ EXCHANGE OF POTATO GROWN IN KSC'S BIOMASS PRODUCTION CHAMBER.

G.W. Stutte*, R.M. Wheeler and B.V. Peterson, The Bionetics Corp. (gws, bvp) and NASA Biomedical Operations (rmw), Kennedy Space Center, FL 32899

To characterize $CO_2$ exchange, potatoes (*Solanum tuberosum* cv. Norland) were grown for 90 and 105 days in KSC's Biomass Production Chamber, a 116 $m^{-3}$ closed cuvette, with 0.5 strength modified Hoagland



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solution using recirculating NFT culture, 12/12 photoperiod, 1000 μmol $mol^{-1}$ $CO_2$, and approximately 900 μmol $m^{-2}$ $s^{-1}$ PPF from HPS lamps. Canopy gas exchange responses to $CO_2$ concentration, light intensity, and photoperiod were experimentally determined. $CO_2$ exchange showed a linear response to PPF (up to 1100 μmol $m^{-2}$ $s^{-1}$ max.) and a light compensation point of about 150 μmol $m^{-2}$ $s^{-1}$. Sustained exchange rates of >45 μmol $CO_2$ $m^{-2}$ $s^{-1}$ were obtained 50 days after planting. $CO_2$ saturation was approximately 1200 μmol $mol^{-1}$ $CO_2$ with a compensation point < 100 μmol $mol^{-1}$. A dark cycle of less than 4 hours resulted in a rapid, continuous decrease in $CO_2$ exchange rate which was partially reversed by a 12-hour dark cycle. There was a weak correlation $CO_2$ exchange and leaf starch concentration at the end of the dark cycle.

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CONTROL OF LEAF CUPPING ON CUCUMBERS IN CONTROLLED ENVIRONMENTS
T.W. Tibbitts and J.E. Staub, Dept. of Horticulture, Univ. of Wisconsin, Madison, WI 53706, B.V. Peterson, Bio-3, Kennedy Space Center, FL 32899.

Cucumber plants commonly are found to develop a marginal necrosis of leaves when grown in controlled environments. When occurring on developing leaves, it results in cupping of leaves. Studies in the University of Wisconsin Biotron have shown that the injury is initiated in the hydathodes and produces a chlorosis and necrosis of the 2-4 mm marginal area. Sepals become necrotic and fail to elongate. Petal size is reduced and flowers sometimes fail to open, yet tendrils are not affected. No injury occurs in certain rooms of the Biotron. Transfer of plants from 'clean' rooms to 'contaminated' rooms can produce injury within 48 hours. It can be eliminated by the use of activated charcoal or potassium permanganate filters on the incoming air or through use of water sprays in the air stream. Mineral analysis of tissues from the margins of the leaves provided no evidence of toxic or deficient levels of any nutrients. Gas chromatography and mass spectrometry analysis of air samples from the growing rooms are being undertaken to help identify the casual agent.

151
TEMPERATURE AFFECTS PLANT GROWTH AND SULFUR UTILIZATION IN ONION (*Allium cepa*)
William M. Randle, M.L. Bussard and D.F. Warnock, Department of Horticulture, University of Georgia, Athens, GA 30602-7273

'Willamette Sweet' onions were grown at 10, 17, 24 and 31 C in controlled environment chambers to determine the effect of temperature on plant growth and sulfur utilization in non- and bulb-inducing photoperiods. Plants were first grown for 11 weeks at a 10 hour (non-bulbing) photoperiod and then for 4 weeks at a 16 hour (bulbing) photoperiod. Plants were fertilized weekly 200 ppm 20-20-20 soluble fertilizer containing 7 percent sulfur. Plants had greatest and least growth at 24 and 10 C, respectively in the 10 hour photoperiod while bulb maturation was greatest at 30 C in the 16 hour photoperiod. Leaf sulfur concentration increased linearly in plants grown from 10 to 30 C in the 10 hour photoperiod. Bulb sulfur concentration in plants grown at 30 C was twice that of plants grown at 20 or 15 C in the 16 hour photoperiod.

152
**GROWTH ANALYSIS OF UV-B IRRADIATED CUCUMBER SEEDLINGS AS INFLUENCED BY PAR SOURCE AND CULTIVAR**
Donald T. Krizek*, Roman M. Mirecki, and George F. Kramer, Climate Stress Laboratory, NRI, ARS, U. S. Department of Agriculture, Beltsville, MD 20705

A growth analysis was made of UV-B sensitive ('Poinsett') and insensitive ('Ashley') cultivars of Cucumis sativus L. grown in growth chambers at 600 μmol $m^{-2}$ $s^{-1}$ of photosynthetically active radiation (PAR) provided by red- and far-red-deficient metal halide (MH) or blue- and UV-A- deficient high pressure sodium/deluxe (HPS/DX) lamps. Plants were irradiated 6 h daily with 0.2 (-UV-B) or 18.2 (+UV-B) kJ $m^{-2}$ $d^{-1}$ of biologically effective UV-B for 15 days from time of seeding. In general, plants given +UV-B vs. -UV-B treatment showed lower specific leaf area (SLA) and leaf area ratio (LAR), higher specific leaf mass (SLM), mean relative growth rate (MRGR), and net assimilation rate (NAR), and no difference in leaf mass ratio (LMR). Plants grown under HPS/DX lamps vs. MH lamps had higher SLM and NAR, lower SLA, LAR, and LMR, and no difference in MRGR. Cultivar affected only LMR. PAR source and/or cultivar did not affect plant response to UV-B radiation.

## 86 WORKSHOP 1 (Abstr. 153–157) Novel Laboratory Exercises in Plant Tissue Culture

153
LABORATORY EXERCISES ILLUSTRATING ORGANOGENESIS AND TRANSFORMATION USING CHRYSANTHEMUM CULTIVARS
R. N. Trigiano* and R. A. May, Institute of Agriculture, University of Tennessee, Knoxville, TN 37901-1071, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

A tissue culture laboratory exercise illustrating regeneration of whole plants from leaf segments of Chrysanthemum by organogenesis will be described. Using simple, common media, shoots can be generated in five weeks and rooted after an additional three weeks. Acclimatization of plants can be accomplished in a simple mistbed in the greenhouse. The exercise is adaptable to depict genotype differences among cultivars, optimization of shoot induction, effects of growth regulators, and experimental design. Callus is typically not formed during shoot formation; however, co-cultivation of leaf segments with a virulent strain of Agrobacterium tumefaciens produces callus autotrophic for growth regulators. Co-cultivation with a strain of disarmed A. tumefaciens harboring a NPTII construct affects regeneration of plants resistant to kanamycin.

154
SOMATIC EMBRYOGENESIS IN ORCHARDGRASS
D. J. Gray[1]*, R. N Trigiano[2] and B. V. Conger[3], [1]CFREC-IFAS, University of Florida, 5336 University Ave., Leesburg FL 34748, [2]Department of Ornamental Horticulture and Landscape Design and [3]Plant and Soil Science Department, University of Tennessee, POB 1071, Knoxville, TN 37901-1071

Morphologically-faithful somatic embryos, as well as embryogenic calli, emerge directly from cultured leaf bases of selected orchardgrass clones. The highly embryogenic clone 'Embryogen-P', released by the University of Tennessee, can be maintained in greenhouse pots as a ready source of material for laboratory exercises. To initiate embryogenic cultures, the basal 2 cm of the innermost three leaves are split in half longitudinally, surface disinfested in 25% bleach solution with a drop of detergent for 2 min, then rinsed twice in sterile water. The leaf halves are cut crosswise into 3-5 mm sections, which are placed on solidified Schenk and Hildebrandt's medium containing 3% sucrose and 30 μM dicamba. Cultures are incubated in dark. After 3-6 weeks, small white somatic embryos grow directly on leaf surfaces and friable white embryogenic callus emerges from cut edges or from within leaf sections. Laboratory exercises to be described include a gradient embryogenic response observed in leaves and a unique "split leaf" experimental design that is useful for decreasing experimental variation.

155
A LABORATORY EXERCISE TO DEMONSTRATE DIRECT AND INDIRECT SHOOT ORGANOGENESIS FROM LEAVES OF *TORENIA FOURNIERI*
Mark P. Bridgen* and Madeleine Spencer-Barreto, Department of Plant Science, U-67, 1376 Storrs Road, University of Connecticut, Storrs, CT 06269

Plant cell cultures have the ability to regenerate roots, shoots, leaves, and flowers *de novo*. The production of adventitious shoots *in vitro* is easy to control on *Torenia fournieri* (Wishbone Flower). Direct shoot



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organogenesis is possible to obtain from leaf explants without an intervening callus phase. Leaf explants should be placed on a Murashige and Skoog (MS) basal medium with 6-benzylaminopurine (BAP) levels from 2.5-5 mg/l and indole-3-butyric acid (IBA) at 0.1 mg/liter for direct shoot organogenesis. If leaf explants are placed on a MS medium with 1 mg 2,4-dichlorophenoxyacetic acid (2,4-D) per liter, callus formation will occur. If the callus is subcultured onto a MS medium with 0.5-1.0 mg BAP per liter and 0.1 mg IBA per liter, indirect shoot organogenesis will occur.

156
AN AXILLARY SHOOT PROLIFERATION LABORATORY EXERCISE--MICROPROPAGATING AJUGA REPTANS
John E. Preece* and Carl A. Huetteman, Department of Plant and Soil Science, Southern Illinois University at Carbondale, Carbondale IL 62901.

This exercise was developed for a plant propagation course to demonstrate the 4 stages of micropropagation, the effects of cytokinin concentrations, and the differences between adventitious and axillary shoot proliferation in a short time. Greenhouse-grown stock plants were brought into the laboratory and 4-5 cm long nodal stem segments or shoot tips were surface disinfested for 15 min. in 0.5% NaClO with 1 ml/liter Tween 20 followed by 2 5-min. rinses in sterile water. Working in the open laboratory near the bases of pairs of lit Bunsen burners, students placed either single node or shoot tip explants (2 cm long, 5 reps) onto MS medium with 0, 1, or 10 $\mu$M BA in 150 x 25 mm culture tubes. Cultures were incubated on open laboratory benches. Axillary shoots grew with 0 or 1 $\mu$M BA and most callus and adventitious shoots grew with 10 $\mu$M BA. Microshoots were rooted and acclimatized under mist in the greenhouse.

157
DEMONSTRATING INDIRECT AND DIRECT SHOOT ORGANOGENESIS USING INTERNODES OF *MYRIOPHYLLUM AQUATICUM*
Michael E. Kane* and Nancy L. Philman, Environmental Horticulture Department, University of Florida, Gainesville, FL 32611

There are few plants from which suitable explants can be obtained to reliably demonstrate rapid shoot organogenesis *in vitro*. A laboratory exercise has been developed using internodes of *Myriophyllum aquaticum*, an amphibious water garden plant. Stock shoot cultures are established and maintained *in vitro* from nodal explants cultured on agar-solidified medium consisting of half-strength Murashige & Skoog salts (MS) and 3% sucrose. Students use these cultures as the source of internode explants. Explants are cultured on agar-solidified full-strength MS with 3% sucrose, 100 mg/liter myo-inositol, and 0.4 mg/liter thiamine-HCL and factorial combinations of 0 - 10 $\mu$M 2-isopentenyladenine (2iP) and 0 - 1.0 $\mu$M $\alpha$-naphthaleneacetic acid (NAA). Adventitious shoot development occurs directly from the epidermis within 4 days and is promoted in media supplemented with 2iP alone. Cytokinin supplemented media amended with NAA induce organogenetic callus formation but reduce 2iP promotion of direct shoot organogenesis. At week four direct and indirect shoot organogenesis on the various media are enumerated and statistically analyzed.

## 87 WORKSHOP 2 (Abstr. 158–161) Advances in Citrus Rootstock Research

158
ADVANCES IN CITRUS ROOTSTOCKS
James J. Ferguson,* University of Florida, Horticultural Sciences, P.O. Box 110690, Gainesville, FL 32611-0690

Citrus rootstock improvement has relied historically on clonal selections chosen from traditional field trials and from cold-hardy scion improvement programs. Although the impact of traditional plant breeding programs on citrus rootstock improvement has been limited because of biological impediments and lack of understanding of citrus genetics, newly developed techniques on the cellular and molecular level have provided new opportunities for progress.

Although trends in citrus rootstocks can be monitored through Budwood Registration data, official statistics are generally not available on rootstocks in bearing groves. Traditional screening programs include initial testing for resistance to fungal and viral diseases, nematode susceptibility, and nursery performance followed by evaluation as a budded tree. Rootstock trials underway include hybrids of 'Ruby' orange/trifoliate orange, sweet orange/trifoliate orange, pummelo/trifoliate orange, and 'Changsha' mandarin/trifoliate orange.

159
PROGRESS IN BIOTECHNOLOGICAL MANIPULATION OF CITRUS ROOTSTOCKS
Frederick G. Gmitter, Jr.*, University of Florida, IFAS, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, FL 33850

Citrus rootstock improvement has relied historically on clonal selections chosen on the basis of field performance. A few rootstocks have come inadvertently from cold-hardy citrus scion improvement programs, and these have become the most commonly used rootstocks in Florida citriculture. In addition to biological impediments to genetic progress, the lack of understanding of the genetics underlying important characteristics and the subsequent inability to select superior individuals in an efficient, cost-effective manner have limited the impact of applied plant breeding on citrus rootstock improvement. Genetic research on the cellular and molecular levels, using recently developed techniques, has provided new opportunities for progress. The potential of plant transformation, somatic hybridization, and genome mapping to ameliorate the breeder's efforts at citrus rootstock improvement will be discussed.

160
FLORIDA CITRUS ROOTSTOCKS
Heinz Wutscher*, USDA, ARS Horticultural Research Lab, 2120 Camden Rd., Orlando, FL 32803

The best indicator of trends in citrus rootstocks in Florida is the statistics of registered trees in nurseries collected by the Bureau of Citrus Budwood Registration of the Florida Department of Agriculture and Consumer Services. In 1992, 45.8% of these trees were on Swingle citrumelo (Citrus paradisi Macf. X Poncirus trifoliata [L.] Raf.), 27.9% on Carrizo citrange (C. sinensis [L.] Osbeck X P. trifoliata), 14.8% on Cleopatra mandarin (C. reticulata Blanco), 4.8% on miscellaneous rootstocks (mostly numbered citrumelos and Rangpur X Troyer (C. reticulata hybrid X [C. sinensis X P. trifoliata]), 3.2% on sour orange (C. aurantium L.), 1.9% on Volkamer lemon (C. volkameriana Wester), and 1.2% on rough lemon (C. limon [L.] Burm. f.). There are no official statistics on the rootstocks of existing, mature citrus groves; estimates are 35% on Carrizo, 25% on rough lemon, 20% on sour orange, and 15% on Cleopatra. Very few groves are planted now because of overproduction and depressed prices. In rootstock tests under way, Benton citrange (C. sinensis X P. trifoliata), pummelo X trifoliate orange (C. maxima X P. trifoliata), and Changsha mandarin X trifoliate orange (C. reticulata X P. trifoliata) hybrids look promising.

161
CALIFORNIA CITRUS ROOTSTOCKS
Louise Ferguson, University of California, Davis, at Kearney Agricultural Center, 9240 S. Riverbend Ave, Parlier, CA 93648

Though California is currently not facing the intense disease pressure that led to the development of the Troyer and Carrizo citrange rootstocks (sweet orange X trifoliate orange hybrids) that replaced the sweet orange (Citrus sinensis [L.] Osbeck) rootstocks, the California industry is still actively involved in breeding and evaluating rootstocks.

All potential rootstocks are still screened for the common fungal and viral diseases of citrus as well as for nematode susceptibility and nursery characteristics. The candidates that prove resistant are then evaluated as budded trees for scion compatibility, climatic and edaphic adaptability, and horticultural traits. Currently, rootstocks are not evaluated for salinity.

Currently C-32 and C-35, citrange hybrids of 'Ruby' orange and trifoliate orange (Citrus sinensis [L.] Osbeck and Poncirus trifoliata [L.] Raf.) are being evaluated with a number of navel and Valencia scions. There is also increasing interest in finding compatible productive rootstocks for new mandarin and grapefruit introductions.

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# 88 WORKSHOP 3 (Abstr. 162–165) Alternative Methods of Postharvest Food Protection

162
NEW TECHNOLOGIES FOR IRRADIATION OF FRUITS AND VEGETABLES
G.R. Nonnecke[1]*, D.G. Olson[2], C.A. Reitmeier[3], R.J. Gladon[1], and M.L. Gleason[4]
[1]Department of Horticulture, [2]Utilization Center for Agricultural Products, [3]Department of Food Science and Human Nutrition, and [4]Department of Plant Pathology, Iowa State University, Ames, IA 50011

The fruit and vegetable industry attempts to deliver to the consumer products of the highest quality. Irradiation of fruits and vegetables may allow the industry to achieve this goal more efficiently. A new and devcloping technology for enhancing food quality and safety is irradiation by using an electron beam linear accelerator, a source of high-speed electrons and x-rays. Advantages provided by this method of irradiation, as compared with other forms of irradiation, are: the direct use of electrons or conversion to x-rays; increased flexibility for irradiating a variety of products; variation of the irradiation dosage and energy level; no requirement for specialized safety equipment for installation of the facility; minimum operating cost of the facility when not in use; an immediate electrical disconnection when the facility is not in use; and, the source of energy for irradiation is not radioactive. The technology associated with electron beam irradiation is dynamic and continues to improve as more research is completed. The electron beam linear accelerator facility at Iowa State University has been commissioned and is operational. The facility and the process for irradiation of several agricultural products will be described. Also, preliminary data on electron beam irradiation of strawberries will be presented.

163
FRUIT ROT CONTROL WITH BIOLOGICALLY DERIVED SUBSTANCES
Fumiomi Takeda* and Wojciech Janisiewicz, USDA, ARS, Appalachian Fruit Research Station, 45 Wiltshire Rd., Kearneysville, WV 25430

Postharvest decay represents major losses in the horticultural industry. Synthetic fungicides are an effective tool in controlling postharvest diseases. However, the need for new methods to control postharvest diseases is emphasized because of resistance to certain fungicides, increased incidence of iatrogenic diseases, health risk concerns, and regulatory constraints on pesticide usage.

The use of biologically derived bioactive substances is an alternative approach for the control of postharvest diseases. For example, pyrrolnitrin, a compound produced by Pseudomonas cepacia, has high antifungal activity toward several pathogenic fungi. Chitosan, obtained from deacetylation of chitin, activates the natural defense mechanism in the host tissue. Some volatile compounds from plants and fruits have fungitoxic properties. Hinokitiol, an extract from Japanese cypress trees, is highly effective in extending the shelflife of peaches. The usefulness and limitations of a number of natural bioactive substances will be discussed.

164
EDIBLE COATINGS FOR FRUITS AND VEGETABLES.
Myrna O. Nisperos-Carriedo* and Elizabeth A. Baldwin, USDA Citrus and Subtropical Products Laboratory, P.O. Box 1909, Winter Haven, Florida 33883

Several processes including controlled atmosphere, hypobaric storage and the application of protective films have been developed to extend shelf-life of fruits and vegetables. Recently, the application of edible coatings that can simulate controlled atmosphere storage to prolong product freshness is becoming a popular concept. The ability of these coatings to extend postharvest storage life depends on their differential permeability to $CO_2$ , $O_2$ and water vapor.

This talk will describe the developmental aspect and specific applications of edible coatings on various fresh and minimally processed fruits and vegetables.

165
Measuring the Environmental Impact of Pesticides
Joseph Kovach, New York State Agricultural Experiment Station, Geneva, NY

Traditionally, pesticides used to control insects, weeds and diseases are selected primarily based on their efficacy and/or cost rather than on potential environmental impact. In order to estimate the environmental impact of pesticides used in commercial agriculture, a model was developed called the Environmental Impact Quotient (EIQ). Over 120 pesticides were evaluated using 13 different toxicological criteria (leaching potential, residue potential, carcinogenicity, effect on beneficials, etc.). The EIQ values obtained from these calculations can be used to determine which pesticide is the least toxic choice or which pest management program is likely to have the lowest total environmental impact.

# 89 WORKSHOP 4 (Abstr. 166–169) Strategies of Selection, Introduction, and Release of Asexually Propagated Ornamental Plants

166
INTRODUCTION AND RELEASE OF NEW WOODY LANDSCAPE PLANTS FROM THE UNIVERSITY OF MINNESOTA
Harold Pellett, University of Minnesota Landscape Arboretum, P.O. Box 39, Chanhassen, MN 55317

The woody landscape plant breeding project in Minnesota is a very diverse program. It encompasses a broad spectrum of plant genera & utilizes several different approaches to develop new cultivars. The primary applied objective of the project is to develop high quality, woody landscape plants that are well adapted to the environmental conditions of Minnesota and other northern areas. New cultivars are developed through (1) controlled hybridization, (2) by observation and selection of superior plants growing in the wild or in planted landscapes, (3) from plant populations grown from native seed sources and (4) from plants acquired from seed exchanges, etc. with other arboreta.

Two red maple cultivars are patented. The rest of our introductions have been through the royalty program of the Minnesota Nurserymens' Research Corporation. Brief descriptions of plants introduced from our program will be given and the introduction processes will be described.

167
BREEDING AND PATENTING OF DOUBLE NEW GUINEA IMPATIENS
Lyndon W. Drewlow*, Mikkelsens Incorporated, Ashtabula, Ohio 44004

Development of the Twice As Nice series of double flowered New Guinea Impatiens will be discussed with emphasis on breeding methods used and problems encountered while developing an entirely new flower type in that species of plant. Patenting procedures for a Utility or 101 patent on the double flower characteristics will also be discussed.

168
SHRUB BREEDING ACTIVITIES AT THE U.S. NATIONAL ARBORETUM
Randy Johnson, USDA, ARS, U.S. National Arboretum, 3501 New York Ave. NE, Washington DC 20002-1958

A primary mission of the research unit at the U.S. National Arboretum (USNA) is to develop landscape trees and shrubs which are pest resistant and tolerant of environmental stresses. These improved trees and shrubs will ultimately enhance environmental quality. Breeding, early screening, and evaluation activities are carried out at USNA. Superior selections are



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further evaluated through a cooperative evaluation program of private nurseries and public institutions located throughout the U.S. If the selection is deemed "superior" by the cooperators it is named, released through the USDA, registered with the appropriate International Registration Authority, and distributed to our stock increase cooperators. These cooperators are private nurseries which produce liners for the industry. All material is provided free of charge and is not patented or trademarked. The USNA provides some marketing support in the form of publishing the releases in scientific and trade journals.

169
SELECTION AND INTRODUCTION OF WOODY LANDSCAPE ORNAMENTALS AT THE UNIVERSITY OF GEORGIA
Michael A. Dirr, Allan M. Armitage, and Orville M. Lindstrom, Jr., Department of Horticulture, University of Georgia, Athens, GA 30602

The Department of Horticulture has introduced over 20 new plants into the Georgia and southern nursery trades. The program serves as a conduit for evaluating and distributing plants from the U.S. National Arboretum, Arnold Arboretum, individuals and nurseries. Propagation requirements and cold hardiness estimates are determined for most of the potential introductions. Cooperating nurseries provide real-world assessments of container and field cultural criteria. Further, plants are tested under field conditions at the Department's research farm. Plants are promoted through lectures, articles, and distribution to any interested Georgia nursery. Numerous trade, popular, and refereed articles were spawned from the program. Selected plants have been provided to commercial tissue culture labs for stock increase.

To date, the University has realized no financial return. A genuine need exists to generate income from royalties to sustain and enlarge the program.

A list of the Georgia introductions will be available to all participants and several of the more notable introductions will be discussed.

## 90 WORKSHOP 5 (Abstr. 170–172) New Chemical and Biological Treatments for Horticultural Seeds

170
FILM COATING OF HORTICULTURAL SEEDS, BENEFITS AND DIFFICULTIES.
Hossein Robani*, Ferry Morse Seed Company, P.O. Box 4938, Modesto, CA. 95356.

Film coating is a process of depositing a thin but uniform coating material onto the surface of the seed. The film coating may contain polymers, pesticides, fungicides, biologicals, pigments or colorants, and other additives. Film coating will provide uniform placement of the seed treatment chemicals on the seed, is essentially dust free, safe to handle, improve flowability of the seed, and has bright color and nice appearance. However application process is slow and requires expensive machinery. The vegetable seed companies are an attractive market place for manufacturer of pharmaceutical coating polymers and film coating machineries. basic application methods, available film coating materials and machinery, and seed storage and viability will be discussed.

171
BIOLOGICAL SEED TREATMENTS USING TRICHODERMA HARZIANUM FOR HORTICULTURAL CROPS
A. G. Taylor*, G. E. Harman and P. A. Nielsen, Department of Horticultural Sciences, New York State Agricultural Experiment Station, Cornell University, Geneva, NY 14456

Biological seed treatments provides an alternative to chemical seed treatments or may also be used in combination with chemicals for effective control of plant pathogens. Seed treatment technologies are an important component of pest management, especially for effective biological control. Several seed treatments have been developed and evaluated to increase efficacy of the bioprotectant, *Trichoderma harzianum* , including 1) suspending the bioprotectant in a binder for a slurry application, 2) use of film coating technology, termed liquid coating, 3) combination of physiological treatments such as priming with the biological and 4) a dry planter box formulation. A laboratory bioassay consisting of sowing cucumber seeds in *Pythium* or other pathogen infested soil has shown that seed treatment technologies can enhance the efficacy of the bioprotectant. Field research has been conducted over four growing seasons on standard sugary and sh2 sweet corn. In general, emergence from seeds treated with *Trichoderma* by the described methods was comparable to seeds treated with chemical pesticides. Furthermore, plant growth was enhanced in several field studies.

172
NEW CHEMICAL TREATMENTS FOR HORTICULTURAL SEEDS
Kyle W. Rushing, Gustafson, Inc. Dallas, Texas

The utilization of seed applied pesticides has been lacking in the area of horticulture for many years. Rather than relying on this type of pesticide application, most commercial producers have utilized soil drenches, dips, granular and foliar spray applications to provide the desired control. As a result of the recent Benlate incidents, the chemical industry will continue to be reluctant to register products for seed treatment, granular and foliar applications. The potential liability that exists from these product uses makes it impossible for chemical companies to accept this responsibility. A discussion of those products that are available as seed treatments is restricted to two products, i.e., Thiram 42-S and Vitavax -34. The limitation of the product use patterns and a discussion of potential options will be made. EPA's document on warranties, disclaimers and limitations on pesticide labels will be discussed as it relates to pesticide uses.

## 91 WORKSHOP 6 (Abstr. 173–177) Lipid Peroxidation and Plant Tissue Disorders

173
BIOLOGICAL ROLES AND BIOCHEMISTRY OF THE LIPOXYGENASE PATHWAY
Harold W. Gardner, USDA, ARS, National Center for Agricultural Utilization Research, Phytoproducts Research, Peoria, IL 61604

Two branches of the lipoxygenase pathway seem to universally predominate in plants. One such pathway involves chain-cleavage of fatty acid hydroperoxides into aldehydes, and another is chain cyclization of a linolenic hydroperoxide with eventual transformation into jasmonates. The aldehyde pathway, which furnishes green-grassy or cucumber-like odors, is triggered by wounding or pathogen attack. The aldehydes generated are defensive against the growth of pathogenic bacteria/fungi. Recently, the aldehyde pathway has been extended to include the transformation of *cis*-3-hexenal and *cis*-3-nonenal into 4-hydroxy-2-hexenal and 4-hydroxy-2-nonenal, respectively, the latter of which are cytotoxic. The other pathway leads to the biosynthesis of the jasmonate phytohormones. The initial biosynthetic product, 7-iso-jasmonic acid, becomes converted into jasmonic acid, as well as a large family of related compounds. The jasmonates control diverse physiological processes, such as induction of proteins, defensive enzymes, tuberization, secondary metabolites, and senescence.

174
LIPID PEROXIDATION AND PLANT TISSUE DISORDERS
Anton Novacky*, Dept. Plant Pathology, Univ. Missouri, Columbia, MO 65211

Increased solute leakage resulting from ozone injury, senescence, wounding and virus or bacteria-induced hypersensitive reaction [HR] have been related to membrane lipid peroxidation [LPX]. The genesis of LPX in various situations may derive from several different processes: a) the direct addition of $O_2$ to unsaturated fatty acids forming hydroperoxide in an enzymatic reaction catalyzed



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by lipoxygenase, an enzyme widely distributed in plant seed, root, and leaf tissue or b) peroxidation by active oxygen species [AO], e.g. $O_2^-$ and $H_2O_2$, that are generated during normal cellular metabolic activities. Increased production of AO could occur as the result of a metabolic change or a reduction in the amount or activities of antioxidants, i.e. ascorbic acid, vitamin E, and glutathione, and the detoxifying enzymes catalase and superoxide dismutase. The HR against plant pathogenic bacteria and viruses will be used as case histories to discuss the genesis of lipid peroxidation.

175
APPLE SCALD: RE-EXAMINATION OF THE PEROXIDATIONS BELIEVED TO BE ITS CAUSE
William J. Bramlage* and Zhanyuan Du, University of Massachusetts, Amherst, MA 01003

Superficial scald of apples is believed to be caused by the oxidation of α-farnesene to conjugated trienes, which then perturb membrane lipids and cause cell death. The antioxidant diphenylamine that is used for commercial scald control is believed to inhibit α-farnesene oxidation. However, measurement of TBA-reactive substrates and total peroxides in apple peel showed that marked increases occurred as fruit senesced, but only slight changes were associated with conditions that specifically led to scald development. Similarly, changes in activity of catalase, peroxidase, and SOD occurred as fruit senescent progressed, but changes in these enzymes had no association with conditions that promoted scald development. We also found that DPA primarily affected accumulation of α-farnesene, with only a small effect on its oxidation to conjugated trienes. These results cast doubt on the hypothesis that lipid peroxidation in membranes produces superficial scald on apples.

176
LOCALIZATION OF PEROXIDIZED LIPIDS IN DETERIOSOMES
J.E. Thompson and K. Yao, Department of Biology, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1

Fluorescent peroxidized lipids are present in lipid extracts of microsomal membranes and cytosol from young and senescing bean (*Phaseolus vulgaris*) cotyledon tissue. For young tissue, the peroxidized membrane lipids are mainly phospholipids, whereas those in the cytosol are primarily free fatty acids. With advancing senescence, microsomal peroxidized lipids increase by 200% relative to membrane protein and by 50% on a per cotyledon basis, and the increase is mainly attributable to enhanced levels of peroxidized free acids. Cytosolic peroxidized lipids expressed on a per cotyledon basis decline by 55% over the same period. Fractionation of the cytosol revealed that, for both young and senescing tissue, ~50% of the cytosolic fluorescent peroxidized lipids are associated with deteriosomes, which are nonsedimentable microvesicles formed from membranes and enriched in phospholipid catabolites. Moreover, the decline in cytosolic peroxidized lipids with advancing senescence correlates with progressive impairment of deteriosome formation. Deteriosomes also contain high levels of polyunsaturated free fatty acids and exhibit strong lipoxygenase activity.

177
TOWARD A COMPREHENSIVE MODEL FOR LIPID PEROXIDATION IN PLANT TISSUE DISORDERS
Robert L. Shewfelt, Food Safety and Quality Enhancement Laboratory, University of Georgia Experiment Station, Griffin, GA 30223-1797

Lipid peroxidation has been observed in seed aging, hypersensitive reaction, senescence and stress response to high temperatures, chilling, freezing, drought and pollutants. It is not clear whether peroxidation represents a primary cause of any of these events or merely a secondary effect. A body of evidence is accumulating that suggests the source of initiation is not as important as the balance between degradative reactions and endogenous defense mechanisms within the membrane. Furthermore, different membranes within the cell show differences in susceptibility to peroxidative challenge suggesting that localization is critical for a peroxidative link to these disorders. A comprehensive model is presented that accounts for disparate symptomology across a wide range of disorders and horticultural crops with peroxidation as a critical controllable event.

## 92 WORKSHOP 7 (Abstr. 178–181) Sustainability of Vegetable Breeders' Genetic Resources

178
SUSTAINABILITY OF VEGETABLE GERMPLASM - HAVE WE BEEN TOO EFFICIENT FOR OUR OWN GOOD: THE CIP CASE.
Wanda W. Collins*, Department of Horticultural Science, Box 7609, North Carolina State University, Raleigh, NC 27695

Valuable vegetable genetic resources exist in potentially precarious survival situations in developing countries. This germplasm is often in the hands of local farmers who do not have the resources to maintain material with no immediate and apparent benefit to them. Concerns have been raised about the breeding activities of international agricultural research centers whose efforts are linked with national agricultural research system (NARS) efforts to introduce improved cultivars directly to these farmers. Critics have maintained that the introduction and availability of improved vegetable genotypes have endangered the survival of important land-races, other locally adapted materials, and even wild species. Are these concerns justified? The International Potato Center (CIP) has been involved in potato cultivar improvement for 20 years. The impacts of their improvement program on NARS, local farmers and survival of important native germplasm will be examined.

179
CONSERVING AND USING CROP GENETIC RESOURCE COLLECTIONS: THE CONTRIBUTION OF PUBLIC SECTOR PLANT BREEDERS, GENETICISTS, & CURATORS
Laura C. Merrick, Sustainable Agriculture Program, University of Maine, 5722 Deering Hall, Orono, ME 04469-5722

The number and status of germplasm collections associated with plant breeding and applied genetics programs at U.S. public sector institutions [i.e., at both state (SAES) and federal (USDA ARS) agricultural experiment stations] was assessed from a resource conservation perspective via a questionnaire sent to over 1300 people who have been involved with the use or conservation of crop genetic resources in research, preservation, administration, or advisory capacities. The latter so-called working collections typically emphasize use rather than conservation of germplasm, while in turn preservation is one of the primary functions of genebank collections such as those managed by USDA's National Plant Germplasm System. A major objective of the project was to assess the vulnerability of germplasm in working collections to being discarded or left in limbo when breeding programs are discontinued. An evaluation was made of "who is breeding or conserving what crops and where" in order to determine patterns of investment in genetic improvement of major vs. minor crops, as well as in federal- vs. state-based activities. Such differences may be relevant when devising plans to improve germplasm conservation and use. Specific examples of breeding and conservation activity relating to vegetable crops will be compared to that of other types of crop commodities.

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SAVING GERMPLASM BY UTILIZING IT
James L. Brewbaker*, Professor of Horticulture and Genetics, University of Hawaii, Honolulu, HI 96822

The genetic resources of most horticultural and forestry species often vastly exceed the limited germplasm entering cultivars in farmers' fields. The vulnerability of the narrow germplasm base of commercial cultivars is familiar to all vegetable breeders. It is most evident in the limited general resistance of commercial cultivars to diseases, pests, and environmental stresses. Nowhere is this more evident than in sweet corn. Development of supersweet corns for pesticide-free production in the tropics has led to the successful exploitation of tropical field-corn germplasm heretofore little used in breeding. New market flexibility in exploiting odd colors, shapes, sizes, flavors, and ecosystems (e.g., the tropics) is expanding the germplasm base of many vegetables. Saving germplasm by its utilization must involve the construct of broad-based composites and synthetics, and of core collections in gene banks. It must involve public fund commitment to long-range breeding as a means of germplasm preservation, and not only in international centers of agricultural research.



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GENETIC MARKERS AND PLANT GENETIC RESOURCE MANAGEMENT

Peter K. Bretting* and Mark P. Widrlechner, USDA/ARS North Central Regional Plant Introduction Station, Iowa State University, Ames, IA 50011

When suitably deployed, genetic markers facilitate all phases of plant genetic resource management, from acquisition through enhancement. This paper will review the kinds of plant genetic resources and genetic markers, analytical methods for marker data, and specific applications of genetic markers to plant genetic resource management, such as (i) assessing a collection's "gaps" and redundancy; sampling strategies; characterizing newly acquired germplasm; maintaining "trueness to type"; monitoring genetic shifts; monitoring germplasm viability and health; developing optimal utilization strategies from genetic marker data; exploiting associations among horticulturally meritorious traits and genetic markers. Finally, general conclusions and forecasts regarding future prospects for applying genetic markers to these tasks will be presented.

# 104 COLLOQUIUM 2 (Abstr. 182–187) Lightly Processed Fruits and Vegetables

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MARKETING OF LIGHTLY PROCESSED FRUITS AND VEGETABLES

Donald Schlimme, Food Science Program, University of Maryland, College Park, MD 20742

The U.S. marketplace has been especially receptive and attuned to growth in per-capita consumption of fresh produce for both at home and away from home use. In the next 30 years, the USDA projects that consumption of fresh produce will increase 72 to 84%. With this in mind, consumers have demanded fresh produce which can be consumed with less preparation time while maintaining high standards of quality. Attention to quality, greater convenience and maximum safety will be called for to continue increased consumption during the economic uncertainties of the 90's and beyond. Marketing, storage, and distribution factors necessary to sustain the growth of lightly processed produce consumption now and in the next 10 years will be discussed.

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PHYSIOLOGY OF LIGHTLY PROCESSED FRUITS AND VEGETABLES

Jeffrey K. Brecht, Horticultural Sciences Department, University of Florida, Gainesville, FL 32611-0690

The physiology of lightly processed fruits and vegetables is essentially the physiology of wounded tissue. This type of processing involves slicing, chopping, peeling or abrasion. The wounded tissue responds with increased respiration and ethylene production, and, in some cases, induction of wound-healing processes. Other consequences of wounding include oxidative browning, membrane lipid degradation, and enhanced water loss. Appearance of new RNA and protein species in wounded tissue provides evidence for genomic control of the response. Factors affecting the wound response include species and cultivar, stage of physiological maturity, extent of wounding, temperature, $O_2$ and $CO_2$ concentrations, water vapor pressure, and various inhibitors. Immediate rinsing of the wounded tissue may minimize some wound responses by removing the contents of broken cells; adjusting the pH of the rinse solution and including various chemicals may inhibit related enzymatic processes.

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SANITATION OF LIGHTLY PROCESSED FRUITS AND VEGETABLES

William C. Hurst, Department of Food Science and Technology, University of Georgia, Athens, GA 30602

Fresh produce processing (lightly processed fruits and vegetables) is a new, emerging industry offering nutritious, convenient products with fresh-like qualities. The two real-life challenges facing produce processors are sanitation and temperature management. Safety considerations exist because of the potential for hazardous bacteria to grow at refrigerated temperatures. Even with refrigeration, product shelf-life is minimal. Sanitary guidelines must be developed to encompass both processing plants and employees. Research is needed in three areas--modified atmospheric packaging, product surface discolorations, and pest control to ensure that products remain competitive in the marketplace. Educational programs must be developed to combat complacency among employees concerning sanitary habits and temperature abuse during processing, storage and distribution of fresh-cut products to customer markets.

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PREDICTING FILM PACKAGING NEEDS FOR LIGHTLY PROCESSED FRUITS AND VEGETABLES

Arthur C. Cameron, Department of Horticulture, Michigan State University, East Lansing, MI 48824

Packaging films are currently used to modify the environment surrounding most lightly processed fruits and vegetables. For some produce, it has been demonstrated that low $O_2$ and/or elevated $CO_2$ will maintain quality and extend shelf life. For others, reduction of water loss may be of more importance. We have developed a model which can be used to design packages for concurrent modification of both $O_2$ and $H_2O$. The effect of variation in respiration from one batch of product to another on resultant $O_2$ levels in packages will be discussed in relation to the risk associated with excessively low levels of package $O_2$. Such low levels of $O_2$ not only impair the quality of the product but provide a favorable environment for development of dangerous human pathogens. There is also risk associated with inadvertent increases in temperature during handling and marketing. For environmental considerations, it is desirable to use films which can be reused and/or recycled. The impact of these variables on the prediction of appropriate films and designs for packaging will be discussed.

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EDIBLE COATINGS FOR LIGHTLY PROCESSED FRUITS AND VEGETABLES

Elizabeth A. Baldwin* and Myrna O. Nisperos-Carriedo, USDA, ARS, Citrus and Subtropical Products Lab., P.O. Box 1909, Winter Haven, FL 33883-1909

Minimal processing is defined as handling, preparation, and distribution of agricultural commodities in a fresh state. Cutting fresh produce results in injury, cell leakage and accelerated perishability. The presence of an artificial barrier to gas and moisture diffusion ideally would reduce moisture loss, decrease levels of internal oxygen, increase internal carbon dioxide, reduce respiration rate and wound ethylene production, and delay ripening/senescence. In practice, the degree to which the above factors can be altered for a given commodity depends on species, cultivar, surface-to-volume ratio, respiration rate, etc. An edible coating, as an artificial barrier, is made from renewable resources, is biodegradable and can be used as a carrier for antioxidants, artificial colors, flavors, growth regulators, enzyme inhibitors and preservatives. The cutting of produce, however, results in a high moisture surface which presents special problems for coating adherence and microbial control. Recent research on coating of cut mushrooms, celery, apples, pears and peeled carrots, to maintain texture and reduce discoloration, with edible composite coatings will be discussed.

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CULTIVAR CHARACTERISTICS--LIGHTLY PROCESSED FRUITS AND VEGETABLES

William Romig, Freshworld, 700 Professional Plaza, Cinnaminson, NJ 08077

To date, fruit and vegetable varieties have not been developed with the lightly processed segment of the market in mind. Cultivars have been developed for the processed industry and for fresh market. However, manufacturers of lightly processed foods have relied on their ability to select from pre-existing varieties which are best suited to their process. Occasionally, varieties have been developed with a lightly processed product in mind, but the variety was not developed with the process in mind but with the desired consumer attributes. In most cases, the manufacturer of lightly processed fruits and vegetables is using the same variety and harvested lot for bulk produce and lightly processed products, in which case the breeders priorities for bulk produce may not be the same as for lightly processed foods. For example, the breeder will target yield, disease resistance, sensory, and perhaps shelf life for whole produce. However, he/she tends not to be concerned with

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sensory attributes of pre-cut products or the shelf life of the variety prior to or post processing. The value added to pre-cut or lightly processed foods and potential market size will eventually determine if the development of varieties exhibiting specific attributes for this market segment is warranted. Positive business analysis may dictate the development of varieties with specific geometric dimensions, resistance to specific postharvest disorders, reduced levels of substrates or key enzymes controlling sensory attributes or shelf life characteristics, etc. Using a few key examples, the author will illustrate how characteristics desired in lightly processed are driving the development of new varieties.

# 105 ORAL SESSION 21 (Abstr. 188–194) Vegetable Crops: Culture and Management II

188

## EFFECTS OF BRASSICA RESIDUES ON ASPARAGUS DECLINE SYNDROME AND PLANT GROWTH

Marshall K. Elson* and John F. Kelly, Department of Horticulture, Michigan State University, E. Lansing MI 48824; and Hugh C. Price, Department of Horticultural Science, New York State Agricultural Experiment Station, Geneva, NY 14456

Asparagus Decline Syndrome is caused by Fusarium oxysporum f.sp. asparagi (FOA) and Fusarium moniliforme (FM). Resistant asparagus varieties have not been found and chemicals are often ineffective against Fusarium spp. Cabbage (Brassica oleracea) residue has been shown to reduce Fusarium infection in cabbage. However, canola (Brassica napus) also reduces yields in wheat.

Seven Brassicas were selected for testing in the greenhouse and field (Kale, Turnip, Glacier Canola, Global Canola, Yellow Mustard, Dwarf Essex Canola, Humus Canola). Brassica residue added to soil reduced root growth of asparagus, wheat, cress, cucumber, and cabbage seedlings upto 4 weeks. Brassicas grown in the field reduced FOA populations and the incidence of Fusarium infection, but did not inhibit plant growth. Extraction of Brassica residue did not yield any non-volatile Fusarium-inhibitory compounds.

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## USE OF REFLECTIVE MULCHES FOR CONTROL OF MOSAIC VIRUS DISEASE AND REDUCTION IN APHID VECTOR IN SUMMER SQUASH

J.E. Brown*, M.D. Henshaw, J.M. Dangler and F.M. Woods, Department of Horticulture, AAES, Auburn University, AL 36849

Silver reflective plastic mulches were compared with conventional bare ground culture for the reduction of aphids, and mosaic virus diseases as follows: Cucumber Mosaic, Watermelon Mosaic I and II, Zucchini Yellows Mosaic, and Squash Mosaic. Silver plastic mulch produced higher marketable yields than the bare ground treatments. Other colors (white, yellow, and black plastic with yellow edges) of plastic mulch treatments were intermediate in their effects on aphid population and virus disease reduction. Silver reflective mulch alone and silver reflective mulch with insecticide were superior to other colors of plastic mulch in reducing aphid populations. Silver reflective plastic mulch, with or without insecticide, resulted in 10-13 days delay in the onset of the above mentioned mosaic disease.

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## CULTURAL PRACTICES INFLUENCE DILL PRODUCTIVITY IN THE SOUTHEASTERN UNITED STATES

**Thelma Miller*, Owusu Bandele, Marion Javius, Oscar Udoh, and Byron Belvitt Dept. of Plant and Soil Sciences, Southern University and A & M College, Baton Rouge, LA 70813**

**The effects of planting density and N fertilizer rate on fresh yield of 'Long Island Mammoth' dill (*Anethum graveolens* L.) were evaluated using a split plot design. Planting density (one versus two row beds) was the main plot treatment and N rate, the subplot treatment. High, medium and low N rates were 0, 56 and 112 kg/ha in 1990, but 28, 56 and 112 kg/ha in 1992, respectively. P and K were applied at rates of 59 and 111 kg/ha, respectively. In 1990 yields increased as N rate increased. In 1992 the medium N rate produced greater yields than did the high rate, but yields from plots receiving the low N rate did not differ from those receiving other treatments. Planting density did not significantly affect yield in either year. In a second study four, cultivars ('Bouquet', 'Crown', 'Long Island Mammoth' and 'Tetra') were evaluated in 1990 using a randomized complete block design with N applied at 56 kg/ha. 'Dukat' and 'Fernleaf' were added in 1992. Cultivar yields differed only in 1992 when 'Long Island Mammoth' outyielded 'Crown' and 'Fernleaf'.**

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## WATER APPLICATION SCHEDULING BY PAN EVAPORATION FOR DRIP-IRRIGATED TOMATO

S.J. Locascio*, and A.G. Smajstrla, Horticultural Sciences Dept. and Agricultural Engineering Dept., University of Florida, Gainesville, FL 32611

Tomatoes (*Lycopersicon esculentum* Mill.) were grown on an Arredondo fine sandy soil to evaluate the effects of water quantity scheduled by pan evaporation using drip irrigation and polyethylene mulch in a three year study. Water was applied at 0, 0.25, 0.50, 0.75, and 1.0 times pan evaporation in one application per day. The response to irrigation varied with rainfall during the three seasons. In an extremely dry season, fruit yields were doubled by irrigation. Total fruit yields were highest with irrigation quantities of 0.75 and 1.0 times pan and significantly lower with 0.25 and 0.50 times pan water quantity. In an extremely wet season, fruit yields were not influenced by water quantities from 0 to 1.0 times pan. In a third season that was wet from the middle to the end of the season, irrigation more than doubled the marketable yield. However, yield increased only from 65.9 $Mt \cdot ha^{-1}$ with 0.25 times pan to 74.1 $Mt \cdot ha^{-1}$ with 0.75 times pan. Tomato leaf N concentrations were reduced slightly with each increase in water quantity applied even though N was applied with drip irrigation.

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## THE INFLUENCE OF ROTATION AND COVER CROP MANAGEMENT ON THE PRODUCTION OF FRESH-MARKET VEGETABLES.

Vasey N. Mwaja* and John B. Masiunas, University of Illinois, Department of Horticulture, Urbana, IL 61801.

The purpose of this study was to determine the effect of rotation and cover crop management on vegetable production. Winter rye (*Secale cereale* L. cv. Wheeler) and hairy vetch (*Vicia villosa* Roth.) were interseeded in the fall. The following spring, tomato, snapbean and cabbage were planted using reduced tillage methods (RT). The RT were to plant into a cover crop desiccated either with glyphosate or by mowing and disking, leaving cover crop residue on the soil surface. A preplant incorporated application of trifluralin was included as the control. The experiment was a split plot with four replications. In 1991, snapbean yields were affected by cover crop management; total yields of cabbage and tomato were not affected. Tomatoes ripened significantly earlier in no-till systems. However, in 1992, the greatest yields were in the conventional production system. Insect infestation of cabbage was greater on bare ground and cover crop disked plots.

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## COVER CROP AND NITROGEN MANAGEMENT INFLUENCE YIELDS OF SEQUENTIALLY PLANTED VEGETABLES

**Owusu Bandele*, Thelma Miller, Marion Javius, Oscar Udoh and Byron Belvitt Department of Plant and Soil Sciences, Southern University and A & M College, Baton Rouge, LA 70813**

**A three year study was conducted in which fall-planted cover crops of hairy vetch, Austrian winter pea and crimson clover were each followed by spring-planted 'Sundance' summer squash and 'Dasher' cucumber. Squash and cucumber crops were followed by fall 'Florida Broadleaf' mustard green and 'Vates' collard, respectively. The same vegetable sequences were also planted without benefit of cover crop. Three nitrogen (N) rates were applied to each vegetable crop. Biomass and resulting N contribution of Austrian winter pea were inconsistent when compared to the other covers. Spring vegetables following crimson clover generally outyielded vegetables in the other sequences. Effects of cover on fall crops were greatest during the third year when vegetable yields following clover again exceeded yields from other sequences. Elimination of N fertilizer resulted in reduced yields for all crops, but yields of crops receiving one-half the recommended N rate were generally comparable to those receiving the full rate.**



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THE EFFECT OF RHYZOSPHERE PH ON THE ROOT DEVELOPMENT OF CUCUMBER AND CANTALOUPE.

A.F.; Abou-hadid, M.M; Saleh,* M.A. Medany, and A.S., EL-Beltagy, Faculty of Agriculture, Ain-Shams University and Veg. Res. Dept., A.R.C P.O. Box 68 Hadaek Shobra. 11241 Cairo, Egypt.

Cucumber (Cucumis sativus L.) and cantaloupe (Cucumis melo var. Cantaloupensis L.) seedlings have been subjected to a wide range of rhyzosphere pH. Each plant was grown in one pot in water culture. The results obtained showed a great influence of pH on plant root length, root diameter and number of roots, in addition to the subsequent effect on the vegetative growth. The experiment suggests the importance of rhyzospher pH to produce healthy cucumber and cantaloupe seedlings with the maximum root performance. Obtained date were discussed according to the prevailed microlimatic conditions.

# 106 ORAL SESSION 22 (Abstr. 195–202) Fruits/Nuts: Culture and Management II

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EFFECT OF TRAINING SYSTEM AND IN-ROW SPACING ON EARLY PERFORMANCE OF APPLE.

James R. Schupp, Dept. of Plant, Soil and Envt'l. Sci., Univ. of Maine, Monmouth, ME 04259

A trial was established in 1989 to evaluate the performance of 'McIntosh'/M.26 apple trees trained to central leader, Y-trellis or vertical axe training systems. In-row tree spacings were 1.2, 1.8 or 2.4m with the vertical axe and 1.8, 2.4 and 3.0m with the central leader and Y-trellis trees. Treatments were arranged as a split-plot design with system as the main plot treatment, in-row spacing as the sub-plot treatment, and six replications. In 1991, the vertical axe trees had higher yields than the other two systems. System had no effect on yield in 1992. Trees at 1.8m produced greater yield/ha than trees at 2.4m. Y-trellis trees produced more large fruit than central leader trees, while vertical axe trees produced the fewest large fruit. Trees at 1.2m produced fewer large fruit than at 1.8 or 2.4m in the vertical axe systems. In-row light interception increased as tree spacing dropped from 2.4 to 1.8m. Vertical axe trees intercepted more light within the row than the other two systems.

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$GA_3$ DELAYS MATURITY AND INCREASES FIRMNESS OF PEACH FRUITS.

Daniel L. Ward* and Bradley H. Taylor, Department of Plant and Soil Science, Southern Illinois Univ., Carbondale, IL 62901.

Two experiments were conducted in 1992 to examine the effects of $GA_3$ concentration and date of $GA_3$ application on peach fruit maturation and quality. Concentrations of 0, 24, 48 and 72 mg/l $GA_3$ were applied on 28 June. $GA_3$ at 48 mg/l was applied on 25 May, 10 June, 28 June and 18 July. Mature 'Canadian Harmony' trees were used in a randomized complete block design with 8 blocks. All concentrations of $GA_3$ applied 28 June delayed the weighted average harvest date by ≈2 days. There was a linear increase in concentration of maturity with increasing $GA_3$ concentrations. There was no detectable date of application effect on fruit maturation. There was a small (16%) increase in fruit firmness that was linearly related to increasing $GA_3$ concentration. Fruit firmness was greater with earlier dates of $GA_3$ application.

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THE EFFECT OF IRRIGATION AND/OR LEAF REMOVAL ON FRUIT QUALITY OF REDSKIN PEACH DURING FINAL SWELL

James L. Lasswell* and Josiah W. Worthington, Texas A&M University Research and Extension Center, Rt. 2, Box 00, Stephenville, Tx 76401.

In August, 1992 a preliminary study was conducted to determine how irrigation (I) and/or termination of photosynthesis (by removal of leaves (L) from branches to simulate full shade) would affect peach quality of Redskin peach during final swell. Four treatments (1. w/o I-w/L; 2. w/o I-w/o L; 3. w/I-w/L; 4. w/I-w/o L) with four replicates (R) per treatment (T) were tested. Twenty-one fruit in each T/R were numbered 1 through 21 with a black permanent marker. Fruit size (FS) was measured daily and three fruit were removed from each T/R every two to three days until all fruit were soft ripe, then FS, soluble solids (SS), titratable acidity (TA), ground color (GC), density (D), and firmness (F) were determined for each peach. There were significant treatment differences in FS, D, SS, TA, and SS to TA ratios at some point during the final swell, though SS and D were not different when the fruit became fully ripe. Other parameters measured were not affected by treatments used.

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ROOT-PRUNING EFFECTS ON PEACH TREES OVER 2 YEARS

William C. Olien*[1], R.W. Williamson[2], C.E. Hood[2], and M.E Hardin[1] Departments of Horticulture[1] & Agricultural & Biological Engineering[2], Clemson University, Clemson, SC 29634

Spring frosts frequently reduce peach crop load of in the SE, resulting in excessive shoot growth and shade, reduced fruit bud formation, and increased pruning costs. Root pruning (RP) has been an effective, nonchemical means to reduce excessive growth of apple trees, but response of peach is unknown. Two studies were conducted in 1991 & '92 on 8-year-old trees to determine: (A) effects of RP distance (Redhaven/ and Jefferson/Lovell) and (B) effects of RP frequency (Redhaven/Lovell). In Study A, RP was imposed in 1991 at 30, 60, or 90 cm from the trunk (both sides of row, 45 cm depth), with unpruned controls. Shoot growth and canopy density (PAR absorbance) in '91 were more responsive than yield to RP. Optimum pruning distance was between 60 & 90 cm. There was no residual effect of '91 RP on '92 shoot growth (RP not repeated in '92), but yield was reduced more in '92 than in '91 by '91 RP. In Study B, RP frequency (75 cm from trunk) was imposed as a factorial: - & + RP in '91 x - & + RP in '92. '91 RP reduced shoot growth in '91 & '92, and reduced yield in '92 but not in '91. '91+'92 RP reduced '92 yield more than RP in '91 or '92 alone.

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INFLUENCE OF LONG-TERM ROOT PRUNING ON APPLE TREE ROOT DISTRIBUTION

David C. Ferree, Dept. of Horticulture, Ohio State University, Wooster, OH 44691

'Melrose'/M.26 apple trees were root pruned annually for 8 yrs at full bloom on 2 sides to a depth of 25-35 cm. Spacial distribution was determined by counting roots on the exposed wall (2m x 2.5m area) of a trench and classifying them into 4 size classes. Root pruning caused a reduction in the total number of roots and the ratio of large to small roots in the 0-30 cm soil depth on the side of the tree that had been root pruned. Total number of roots declined in root pruned trees 60 and 90 cm from the trunk in the sample taken perpendicular to the root pruning cut, but not on the side parallel to the root pruning cut. Root number in all 4 size classes declined with depth and exhibited significant linear and quadratic patterns.

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VEGETATIVE ORCHARD FLOOR COVERS CAN REDUCE APPLE TREE ROOTING

Michael L. Parker* and Stuart L. Warren, North Carolina State University, Box 7609, Raleigh, NC 27695-7609

'Redchief Red Delicious'/MM.111 (Malus domestica Borkh.) apple trees were grown for 12 years in six vegetative covers: rye mulch (RM), bare soil (BS) maintained by herbicides, mechanical cultivation (MC), tall fescue (TF), Kentucky bluegrass (KB) and nimblewill (NW). Apple root distribution was determined using the trench profile method. A trench two



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meters long and one meter deep was dug perpendicular to the tree row, 80 cm from both sides of the tree. One meter square grids, sectioned into 10 cm squares, were placed on the profile walls and root diameter and number were recorded. Trees grown in RM had the highest number of roots, greater than all other covers, followed by BS. MC and NW had fewer roots than BS. However, MC and NW were higher than KB and TF. KB had fewer roots than all covers except TF. TF had the lowest number of roots.

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PERFORMANCE OF FOUR PEACH TRAINING SYSTEMS OVER EIGHT YEARS
William C. Olien*, John D. Ridley, D.C. Coston, and M.E Hardin, Department of Horticulture, Clemson University, Clemson, SC 29634

The low density, free-standing Open Center (OC) training system for peach production is inexpensive to establish and maintain. However, a lengthy establishment period is required before profitable yields are obtained and uneven distribution of fruiting wood within and between trees reduces potential fruit production and quality. Redhaven/Lovell trees were planted in 1985 to evaluate four peach training systems: OC, Central Leader (CL), Y-Trellis (YT), & Meadow Orchard (MO) planted at 278, 1111, 2222, & 3333 trees/ha, respectively. YT trees were trained with two scaffold limbs oriented across the row, each supported at the top by one wire (8 feet above ground). MO was managed as the Intensive System described by Erez. Irrigation was not available. Crop was reduced by drought in 1988 and by frost in 1990 & 92. YT produced profitable yields in the third season, with good light distribution throughout the canopy. OC trees required seven years to reach yields of YT. Excessive shoot growth following spring frosts has been difficult to manage in CL and MO, resulting in shading out and loss of fruiting zone. Training system has affected fruit number more than fruit size or quality.

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LEAF AND FRUIT DEVELOPMENT OF 'EMPIRE' APPLE TREES AS INFLUENCED BY SHADING AND FOLIAR MICRONUTRIENTS.
Terence L. Robinson*, and Zhongbo Ren, Dept. of Hort. Sciences, New York State Agric. Exp. Station, Cornell Univ., Geneva, NY 14456

Lower scaffold branches of 'Empire'/M.7 apple trees which were planted in 1975 and trained as Central Leaders were shaded or left exposed from 1986-1988. Foliar micronutrient sprays of N, Zn and B were applied 3 times in the early season of each year to both shaded and exposed scaffold branches in an attempt to improve spur vigor. In 1988 spur and bourse shoot leaf area development and fruit growth were monitored. Shading resulted in greater initial spur leaf area at 3 weeks after bloom but shorter leaf duration. Spurs on shaded branches had lost 2/3 of their leaf area by 11 weeks after full bloom while exposed branches had lost only 25%. Bourse shoot leaf area was greater on exposed branches throughout the season. Foliar sprays of micronutrients did not increase leaf area or leaf duration of either spur leaves or bourse shoot leaves. Fruit growth rate was reduced by shading most in the early season. Final fruit size, color, soluble solids and dry matter were reduced by shading. Foliar micronutrient sprays did not affect fruit growth rate any time during the season or final fruit size, color, soluble solids and dry matter. There was also no interaction of shading and foliar nutrition on fruit size or quality. It appears that the negative effects of shading on spur vigor and fruit quality cannot be reversed by foliar micronutrient sprays.

## 107 ORAL SESSION 23 (Abstr. 203–208) Cross-commodity: Cold Hardiness

203
COLD HARDINESS RESPONSE OF CABERNET SAUVIGNON AND CHARDONNAY GRAPEVINES TO WINTER PRUNING
Robert L. Wample*, Washington State University, Irrigated Agriculture Research and Extension Center, Prosser, WA 99350

At approximately two week intervals starting in mid-December, sets of four vines were pruned either 24, 48, or 72 hours prior to sampling for low temperature exotherm (LTE) analysis of buds. Prepruned samples were compared with unpruned samples. Buds for cold hardiness were taken from the fourth to the sixth node positions from each of the four vines. A total of 30 buds from each of the treatments were used for LTE analysis. In addition to these samples, analysis of bud cold hardiness was also made of these prepruned vines after approximately 3, 6, and 9 weeks and compared to unpruned vines.

Despite the popular view that prepruning or pruning of grapevines during the winter reduces cold hardiness of the remaining buds, no differences were found between treatments during December, January, and February. Additional data on winter injury and budbreak will be presented.

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EVALUATION OF LOW-TEMPERATURE TOLERANCE OF FLORAL AND VASCULAR TISSUES OF VACCINIUM ANGUSTIFOLIUM.
Paul E. Cappiello* and Scott Dunham, University of Maine, 5722 Deering Hall, Orono, ME 04469-5722

Six clones of Vaccinium angustifolium and two clones of V. myrtilloides were studied during the winters of 1991-92 and 1992-93. Plants were evaluated for low temperature tolerance of vascular and reproductive tissues.

Over the course of the study, there was a significant difference in low temperature tolerance of flower bud tissue with respect to stem position. Terminal buds hardened later and to a lesser degree than did those located lower on the stem. In addition, flower primordia and flowers were evaluated for low temperature tolerance. The initiation of visible bud swelling was not accompanied by a significant decrease in hardiness; however a significant change was evident once the corolla became clearly visible. This report will discuss the significance of these findings as they relate to frost protection.

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EFFECT OF PRIMOCANE SUPPRESSION ON YIELD AND COLD HARDINESS OF 'MARION' BLACKBERRY
Neil C. Bell*, Bernadine C. Strik, and Lloyd Martin, Department of Horticulture, Oregon State Univ., ALS 4017, Corvallis, OR 97331

Primocanes were either not cut, or cut at ground level from plants on a single occasion at one month intervals from late April to late July, 1991 and 1992. For each treatment, the coldhardiness of primocane tissues was evaluated on four dates from early November to early February. One-node samples were frozen and an $LT_{50}$ developed for tissues by estimating browning on a 1-5 scale. Data on yield and its components were collected the year after primocane suppression treatments. In 1991, although yield per cane declined linearly with later primocane suppression date, yield per plant was highest for the April suppressed plants. Hardiness of all tissues generally increased from November to January and then decreased. Plants with primocanes suppressed in June and July were significantly hardier than those suppressed earlier. Growing point tissues were the least hardy of those tested. Phloem and cambial tissues were approximately 4°C hardier than the growing point, while the bud base and pith were 12°C and 17°C hardier, respectively. Data for 1992 will also be presented.

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EARLY FALL COLD HARDINESS AND NONSTRUCTRAL CARBOHYDRATE LEVELS IN YOUNG, DROUGHT-STRESSED APPLE AND CRABAPPLE ON DIFFERENT ROOTSTOCKS
Mark A. Longstroth*, R. Thomas Fernandez, James A. Flore, Robert T. Schutzki, and Ronald L. Perry, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325.

One-year-old 'Imperial Gala' on Mark, M.9 EMLA, and MM.111; and 'Indian Summer' on MM.111 and MM.106 rootstocks were planted in a rain exclusion shelter in May 1991. All trees were irrigated. Half the trees were drought stressed and received no water for two, 30-day drought cycles. Four trees from each scionXrootstockXirrigation combination were excavated in mid-October. Nonstructural carbohydrate reserves of stems and roots were determined. Cold hardiness, determined by visual examination of tissue after controlled freezing, was influenced by rootstock, drought, and stem age. Concentrations of several carbohydrates were correlated with cold hardiness. Regression models of carbohydrate concentrations on cold hardiness were significant. Removal of root tissue, which was cold sensitive and had high carbohydrate levels, altered the regression equations. Rootstock significantly influenced root concentrations of sorbitol, sucrose, and starch. Root sorbitol increased following drought stress. Mark and MM.106 roots had the largest increases in sorbitol. Irrigated Mark roots had very low levels of sorbitol.



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COMPARISON OF TISSUE RESPONSES TO COLD HARDENING AND FREEZING IN LEAVES OF CABBAGE (*BRASSICA OLERACEA* VAR. *CAPITATA*)

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

When intact shoots and detached leaves of cold-hardened cabbage were frozen to -16°C the leaf lamina and leaf petiole were the limiting factors, respectively, in leaf survival. Hardened petiole tissues also had a greater ionic conductance than lamina tissues at all test temperatures. Vital staining of petiole sections with 2,3,5-triphenyltetrazolium chloride revealed that vascular bundle tissues survived lethal temperatures while ground parenchyma and collenchyma did not. In both controlled freezing tests with intact shoots and in the field when snow cover prevented soil freezing, petiole temperatures were consistently above air and leaf lamina temperatures. These observations point to a proposed dual mechanism of freeze protection in cabbage involving the innate freezing tolerance of the tissues and the protection of the more cold-sensitive petiole tissues by the presence of unfrozen water in the vascular tissues.

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EFFECTS OF THREE WATERING REGIMES ON COLD HARDINESS OF TWO RHODODENDRON CULTIVARS

Tomasz Anisko* and Orville M. Lindstrom, Dept. of Horticulture, University of Georgia, Georgia Station, Griffin, GA 30223-1797

Plants of two rhododendron cultivars, 'Catawbiense Boursault' and 'Yaku Princess', were subjected to three watering regimes: 100, 200, and 300 ml of water per 1-gallon-container, applied 4 times a week between August 24 and October 2, and twice a week between October 2 and December 18. A freeze test was conducted on January 11. Injury to leaves, stems, and vegetative buds was visually evaluated after 4 and 11 days of incubation at room temperature. Leaves of 'Catawbiense Boursault' plants under "100 ml" watering regime were significantly less injured at temperatures between -10 and -16°C than leaves of plants under "200 ml" and "300 ml" regimes. Stems of this cultivar under "100 ml" regime were significantly more injured at temperatures -28 and -30°C than stems of plants under "200 ml" and "300 ml" regimes. Differences in the injury rating for 'Yaku Princess' plants were not significant for either leaves or stems. Vegetative buds of both cultivars were not injured even at the lowest test temperature, i.e. -30°C.

## 108 ORAL SESSION 24 (Abstr. 209–215)
## Floriculture Nutrition

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PLANT GROWTH AND LEACHATE AS AFFECTED BY CONTROLLED-RELEASE AND LIQUID FERTILIZER

Ursula K. Schuch* and Marylynn V. Yates, Botany and Plant Sciences Dept. and Soil and Environmental Sciences Dept., University of California, Riverside, CA 92521.

Poinsettia (*Euphorbia pulcherrima* 'Gutbier V-14 Glory') were grown using commercially available poinsettia fertilizer of various combinations of controlled-release (CRF) and constant liquid fertilizer (LF). At the end of the production period, plants treated with 83, 165 or 250 mg/l LF only were 10% taller than plants treated with the same concentrations of CRF. The total number of cyathia and the number of open cyathia at harvest was 18% and 50% higher for plants treated with LF only compared to plants treated with CRF only. Plants treated with 165 CRF/ 83 LF or 83 CRF/250 LF were not different compared to 250 CRF/0 LF or 0 CRF/ 250 LF in height, number of cyathia at anthesis, and total number of cyathia at the end of the production period. When LF was changed to clear water 5 weeks before the end of production, nitrate runoff from 83 CRF/250 LF treatment was reduced 30% for the last two weeks, and from the 165 CRF/83 LF treatment nitrate leachate was reduced gradually from 33 to 66% over the 5-week period.

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NITROGEN NUTRITION AND GROWTH ANALYSIS OF POINSETTIA

Mary Ann Rose* and John White, Department of Horticulture, The Pennsylvania State University, University Park, PA 16802.

Objectives of several experiments were 1) to characterize shoot N uptake and recovery efficiency in relation to the growth and development of 'Celebrate 2' and 'Lilo' poinsettias, and 2) to minimize N use in crop production by manipulating the concentration and timing of N application.

'Lilo' had significantly greater shoot N uptake and recovery efficiency than 'Celebrate 2', but the pattern of uptake over the production cycle was similar between cultivars. In the first several weeks after potting, N uptake and recovery efficiency were low. Maximum uptake and recovery efficiency occurred between 6 and 8 weeks after potting. After 8 weeks, and throughout bract development, N uptake decreased.

'Celebrate 2' poinsettias were supplied with either a constant 200 $mg \cdot N \cdot l^{-1}$ (control), or a variable concentration of N that increased or decreased corresponding to N uptake patterns observed in previous experiments. The N uptake curves for these two treatments were similar, and at final harvest (anthesis), there were no significant dry weight, leaf area, or quality differences. By matching the N supply to the N uptake curve, N recovery efficiency increased from 38% to 58%, and 41% less total N was applied compared to the control. The allocation of N and dry weight to leaf, stem, and bract tissue was also similar between treatments.

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NITROGEN LEACHING FROM POTTED POINSETTIA WITH LEACHING FRACTIONS OF 0, 0.2, AND 0.4

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

Single-pinched 'V-14 Glory' poinsettias in 15-cm diameter pots of growing medium received 200 mg/L N constant liquid fertigation from Hoagland solution with N sources of 100% $NO_3$-N and 60% $NO_3$-N:40% $NH_4$-N, P concentrations of 8 and 23 mg/L, and leaching fractions (LFs) of 0, 0.2 and 0.4. There were 26 irrigations during the 13 week study. The total fertigation solution and N applied ranged from 6.5 L and 1.3 g at 0 LF to 14 L and 2.8 g at 0.4 LF. Leachate N concentration ranged from 170 to 850 mg/L. The percentage of applied N in the leachate of 100% $NO_3$-N plants was 57% at 0.2 LF and 76% at 0.4 LF. For 60% $NO_3$-N plants, these losses were 49% at 0.2 LF and 67% at 0.4 LF. For 100% $NO_3$-N plants, the percentage of the applied N found in shoot tissues was 26% for 0 LF, 20% for 0.2 LF, and 15% for 0.4 LF. For 60% $NO_3$-N plants these percentages were 35% for 0 LF, 27% for 0.2 LF and 22% for 0.4 LF. Averaged for both 60% and 100% $NO_3$-N plants, the N in the shoot was partitioned as follows: 43% in leaves, 39% in bracts, and 18% in stems.

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FERTILIZER RATE AND SCHEDULE CAN OPTIMIZE PLANT GROWTH AND MINIMIZE NITROGEN LEACHING

C. A. Conover* and R. T. Poole, University of Florida, IFAS, Central Florida Research and Education Center, Apopka, FL 32703

Codiaeum variegatum (L.) Blume 'Petra' liners were transplanted into 15-cm pots and fertilized using 24N-3.4P-14.2K at a total of either 7.2 or 14.4 g N/pot over a 26-week growing period. Eight fertilizer treatments followed four application schedules at a low and high (double the low) rate. Schedules attempted to maximize fertilizer utilization with applications based on projected plant growth patterns. Irrigation was on an as-needed basis, and all leachate was collected from each pot. Weekly leachate per pot was analyzed for pH, electrical conductivity (EC), and $NH_4$-N and $NO_x$-N content. Plant and color grades, and height change were recorded and elemental tissue analyses done for each plant at experiment termination. Fertilizer rate and schedule affected height change, and pH and EC, as expected. Total mg $NH_4$-N and $NO_x$-N in the leachate increased with increased fertilizer rate. Fertilizer application schedule affected $NH_4$-N content at the high fertilizer rate and $NO_x$-N in the leachate at both fertilizer rates with the optimizing curve treatments leaching the least $NO_x$-N for their respective fertilizer rates. Total mg N/pot (mg $NH_4$-N + mg $NO_x$-N) was significant for both fertilizer rate and schedule.



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PATTERNS OF NITROGEN UPTAKE BY GREENHOUSE ROSES.

Raul I. Cabrera*, Richard Y. Evans and J.L. Paul. Dept. of Environmental Horticulture, University of California, Davis, CA 95616-8587.

A recirculating nutrient solution system was constructed for studying the N uptake by roses in relation to the developmental stage of the crop and light conditions. N and water uptake were measured at 2 to 3 day intervals for a period of 1 year. Daily PPFD was also recorded.

N uptake rates followed a cyclical pattern that was related to shoot development and harvest, but independent of transpiration rate. The N uptake rate changed four- to five-fold during a single cycle of flower shoot growth (e.g., 29 to 146 mg N plant$^{-1}$day$^{-1}$). The lowest N uptake rate occurred when the shoot elongation rate was at its maximum. The highest N uptake rate occurred at about the time the flower shoot reached commercial maturity. Following harvest, the uptake rate remained high for several days, even though there was no shoot growth during that time. There were also seasonal changes in N uptake. The average daily plant N demand was about 30 and 60 to 70 mg plant$^{-1}$day$^{-1}$ during the winter and summer months, respectively. The total annual plant N uptake was in close agreement with the yearly plant N demand calculated for container-grown roses.

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METHOD OF IRRIGATION AND FERTILIZER APPLICATION INFLUENCE GROWTH AND NITROGEN RECOVERY FOR 'SCARLET ELITE' GERANIUM

Patricia R. Knight*, D. Joseph Eakes, and Charles H. Gilliam, Department of Horticulture, Auburn University, AL 36849-5408

Seed geraniums (Pelargonium x hortorum Bailey 'Scarlet Elite') were grown in 10-cm pots in a 1 pine bark : 3 peat : 1 perlite (v:v) medium from 17 April until 1 June 1992. Plants were watered with conventional overhead irrigation (CI) or in ebb and flow troughs (EF) and fertilized with Peter's Geranium Special 15N-6.5P-12.5K (PGS) or Osmocote 14N-6.1P-11.6K (OS). Fertilizer application had no influence on shoot dry weight. Shoot dry weights were greatest for plants given CI. Shoot tissue N was greatest for plants given CI or PGS. Root tissue N was greatest for plants given EF with PGS, and plants watered by CI with OS. Irrigation method had no influence on N remaining in the growing medium. Medium N content was greatest for plants receiving PGS.

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DETERMINING STANDARDS FOR WATER QUALITY IN CLOSED NUTRIENT SYSTEMS FOR DUTCH FLORICULTURE

R. Baas*, F. Buwalda, H. Nijssen, D. van den Berg, Res. Sta. for Floriculture, Linnaeuslaan 2a, 1431 JV Aalsmeer, Netherlands

Glasshouse experiments were carried out to determine the extent NaCl accumulation up to 30 mM decreased production and quality of chrysanthemum, gerbera and carnation. At NaCl concentrations higher than 8 mM (468 ppm), transpiration, flower and peduncle weight decreased. The effects were most pronounced during periods of high irradiation. Vase life was not influenced by NaCl. Na uptake concentration (mmol/l) was linearly related with the concentration in the nutrient solution, and was 8%, 5% and 2% of the external concentration for gerbera, chrysanthemum and carnation, respectively. Compared to Na, Cl uptake was higher and non-linearly related to the outer concentration. Apart from chloride/nitrate antagonism, no clear general interactions were found for other ions in relation to NaCl addition. The results imply that in order to avoid Na accumulation above suboptimal levels, irrigation water in closed nutrient systems should contain less than 0.6, 0.4 and 0.16 mM NaCl for gerbera, chrysanthemum and carnation, respectively.

# 109 ORAL SESSION 25 (Abstr. 216–221) Cross-commodity: Breeding and Genetics II

216

PHYLOGENETIC RELATIONSHIPS OF VERNONIA BASED ON SEED PROTEIN ELECTROPHORETIC VARIATION.

Benjamin Jeyaretnam[1], Sharad C. Phatak[2]* and Hazel Y. Wetzstein[1], Department of Horticulture, University of Georgia, [1]Athens, Ga 30602 and [2]Coastal Plain Experiment Station, Tifton, Ga 31793.

Twenty accessions of Vernonia galamensis (Cass.) Less. from six subspecies were studied to develop a phylogram based on the seed protein profiles on one-dimensional (SDS-PAGE) gel electrophoresis. Soluble protein was extracted with 50 mM Tris-HCl buffer. Resolution factor values (Rf) and molecular weights of different protein profiles were estimated. The percentage similarities among different accessions were calculated and a consensus phylogram was derived using PAUP analysis. Almost all soluble proteins showed a moderate mobility (Rf. 0.2 to 0.6) and resolved as four clusters with varying number of classes. Variety ethiopica was observed to have greater mutational differences from other varieties of same subspecies galamensis and other subspecies. Variety petitiana showed greater genetic deviation to varieties galamensis, australis and pairobensis of the same subspecies galamensis than among the later three. Mutational distances between Subspecies gibbosa, mutomoensis and afromontana were similar.

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MORPHOLOGICAL AND ENZYME CHARACTERIZATION OF AN IMPATIENS GERMPLASM COLLECTION.

V. D. Lerch* and T. J Ng, Institute of Applied Agriculture and Department of Horticulture, University of Maryland, College Park, MD 20742.

An Impatiens germplasm collection consisting of accessions (from Africa, New Guinea [NG[, Sri Lanka, and Java/Celebes, a NG breeding population, and selected interspecific hybrids was characterized for 32 morphological traits and two ensyme systems, peroxidase (PER) and aspartate amino transferase (AAT). Thirteen PER and three AAT isozymes were identified, and both enzyme systems appeared to be co-dominatly inherited. There were unique zymograms for the accessions and the inter-specific hybrids, but not the NG breeding population.

A Generalized Fisher Exact Test indicated that qualitative characters of the accessions were independent of each other, of isozyme traits and of geographical origin of the accession; this was not true for isozymes. Principal component analysis combining both morphological and isozyme traits uniquely separated the accessions while also indicating clusters of similarity. Extensive genetic diversity was indicated for all traits in the accessions and for quantitative traits in the NG breeding population.

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AN INFORMATION INDEX FOR EFFICIENT ANALYSIS OF GENETIC RELATIONSHIPS BASED ON MOLECULAR MARKER DATA

Jan G. Tivang* and Jim Nienhuis, University of Wisconsin, Dept. of Horticulture, University of Wisconsin, Madison, WI 53706.

Variation for molecular markers (RFLPs and RAPDs) can be used to measure genetic relationships among genotypes. The theoretical minimum number of polymorphic bands needed to discriminate among 100 genotypes is seven ($2^7$=128). However, due to redundancy and lack of independence, larger numbers of polymorphic bands are usually required to separate genotypes. This problem can be addressed by using an index that will measure the number of discriminations among the genotypes for a given probe or primer. We have developed an information index that can be used to rank either enzyme-probe or RAPD primer combinations with regard to their ability to discriminate among genotypes. The index has great utility in selection of the most efficient enzyme-probe or RAPD primer combinations in germplasm screening. In addition, the index can also be used to estimate the sampling variance of polymorphic bands without the need for the computer intensive bootstrap procedure.

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INHERITANCE OF COLD TOLERANCE IN CULTIVATED SPECIES OF *OPUNTIA*

J.O. Kuti*, Dept. of Agronomy and Resource Sciences, Hort. Crops Research Lab., Texas A&I University, Kingsville, Texas 78363.

Freezing temperatures limit areas in which prickly pears (*Opuntia* species) can be cultivated for their fruits and nopals.Inheritance of cold tolerance was investigated in three cultivated species of *Opuntia*. Parental, $F_1$, backcross and $F_2$ populations from crosses between *O. ficus-indica* (accession #1271), *O. lindheimeri* (accession #1348) and *O. robusta* (accession #1241) were used. Plants were evaluated for cold tolerance by the conductivity method after 3 hrs in a growth chamber at temperatures ranging from 0° to -15°C and acclimation at 10°/5°C (day/night) for 14 days. Means of each genetic population were calculated and broad and narrow sense heritability estimates were determined. The heritability estimates were generally low with evidence of small additive effects and large environmental effects.

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PILOT PROJECT TO CRYOPRESERVE DORMANT APPLE (Malus sp.) BUDS.

Philip L. Forsline[1]*, Cecil Stushnoff[2], Leigh E. Towill[3], John Waddell[3], and Warren F. Lamboy[1]. [1]USDA-ARS-NAA, Cornell Univ., Geneva, NY 14456, [2]Dept. of Horticulture, Colorado State Univ., Fort Collins, CO 80523, and [3]USDA-ARS-NSSL, Fort Collins, CO 80523.

Dormant buds of 64 apple accessions from the National Germplasm Repository (NGR), Geneva, NY were cryopreserved at the National Seed Storage Laboratory (NSSL), Fort Collins, Co. Initial tests after 1 mon, 1, 2, and 3 years of $LN_2$ storage showed no decline in viability. Storage of 16 cultivars (1988/89 and 1989/90 dormant seasons) with a broad range of cold-hardiness characteristics has shown approx 45% viability by patch budding. Storage from dormant seasons of 1990/91 and 1991/92 included 48 cultivars selected for excellent cold-hardiness characteristics. With approx 85% initial viability of these cultivars, a more sensitive statistical analysis can be performed over years. Overall viability over storage duration and sampling years showed 32 had more than 80%, 55 had more than 50% and only 4 had less than 30%.

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USE OF MINOLTA SPAD 502 CHLOROPHYLL METER FOR SELECTION AND EVALUATION OF SWEET CORN

Carol A. Miles* and Peter Minotti
Cornell University, Dept. of Fruit and Vegetable Science, Ithaca, NY 14853

Sweet corn genotypes were selected, recombined in a half-sib fashion, and evaluated for yield performance at the NYSCALS Experiment Station at Freeville, NY. The objectives of this study were to identify selection criteria associated with N efficiency. Selection and evaluation parameters included chlorophyll readings with the Minolta SPAD 502 chlorophyll meter. The Minolta chlorophyll meter is a rapid, non-destructive method of determining leaf chlorophyll status, and may be an effective tool for evaluating plant N status and thus yield. It is of interest to evaluate plants early in a breeding program for yield potential. Chlorophyll readings were measured at the fifth-leaf stage and at maturity. In 1991, chlorophyll readings were significantly correlated to N concentration (%) and total N content (gm) of the fifth-leaf. Chlorophyll readings measured at the fifth-leaf stage and tasseling were correlated to primary ear fresh and husked weight in 1992. Based on these results, chlorophyll readings were an effective assessment of N status and ear yield.

# 115 ORAL SESSION 26 (Abstr. 222–229) Cross-commodity: Weed Control and Pest Management

222

THE USE OF PLANT GROWTH REGULATORS TO CONTROL EASTERN BLACK NIGHTSHADE (*SOLANUM PTYCANTHUM*) BERRIES.

John B. Masiunas* and Michael P. Crotser, Department of Horticulture, University of Illinois, Urbana, IL 61801.

Eastern black nightshade berries interfere with harvest, stain fruit, and are an undesirable contaminate in processing vegetables. The problem may be reduced if flowering, berry production, and maturity could be regulated. Greenhouse experiments evaluated the effect of commercially available plant growth regulators on eastern black nightshade growth and reproduction. Nightshade were seeded in 10 cm plastic pots and allowed to grow until the reproductive stage. Chlormequat-chloride, ethephon, gibberellic acid, dikegulac sodium, and paclobutazol were applied at standard rates in 90 L $ha^{-1}$ of spray solution using a moving nozzle spray chamber. Nightshade growth, flowering, and berry production were evaluated 3 wk after treatment. Gibberellic acid and ethephon caused leaf chlorosis. Ethephon increased the percentage of ripe berries and decreased the number of flowers per plant.

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EFFECT OF CULTIVAR AND INSECTICIDE SPRAYS ON TARNISHED PLANT BUG INJURY TO STRAWBERRIES

David T. Handley* and James E. Pollard, University of Maine, P.O. Box 179, Monmouth, ME 04259; Plant Biology Dept. University of New Hampshire, Durham, NH 03824

Six strawberry (Fragaria x ananassa Duch.) cultivars known to vary in susceptibility to tarnished plant bug (Lygus lineolaris P. de B.) injury (apical seediness) were grown under three insecticide regimes including no spray, one spray and three sprays, to determine if differences in susceptibility could be used to modify chemical controls for this insect. The most susceptible cultivars harbored more tarnished plant bug nymphs than the least susceptible cultivars. Differences in injury among cultivars was greatest when no insecticide was applied. 'Honeoye' and 'Sparkle' had the least amount of apical seediness, followed by 'Redchief', 'Guardian' and 'Kent'. 'Mic Mac' consistently had the highest level of injury. When insecticide sprays were reduced, apical seediness did not significantly increase for cultivars exhibiting low susceptibility.

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EVALUATION OF LOW-INPUT PECAN ORCHARD FLOOR MANAGEMENT SYSTEMS

N.R. Rice*, M.W. Smith, R.D. Eikenbary, W.L. Tedders, B.W. Wood, G.G. Taylor, B.S. Landgraf, G.E. Barlow, Department of Horticulture and Landscape Architecture, Oklahoma State University, Stillwater, OK 74078

Legume ground covers were evaluated in pecan orchards to reduce nitrogen inputs and increase beneficial insects. Treatments were established at two sites in Oklahoma, each with 5 ha of a 'Dixie' crimson clover/hairy vetch mixture and 5 ha of grass sod. Nitrogen was applied at 0-200 kg·$ha^{-1}$ to the sod plots, but legume plots were not fertilized. Aphids and selected arthropods were monitored on ground covers and in the pecan canopies. Data indicated that a mixture of crimson clover/hairy vetch supplied up to 186 kg·$ha^{-1}$ N to the trees. Beneficial arthropods monitored were Coccinellidae, Chrysopidae, *Nabid*, *Syrphid*, and spiders. Lady beetles, primarily *Hippodamia* and *Coleomegilla*, were the most important aphid predator in the spring, and green lacewing was the most important fall predator. There were fewer aphids infesting pecans using a crimson clover/hairy vetch ground cover than a grass sod.



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## AN ECONOMICAL, EFFECTIVE ALTERNATIVE TO THE AIR-BLAST SPRAYER

D.R. Evert*, P.F. Bertrand, K.A. Harrison, and B.G. Mullinix, Jr., Department of Horticulture, University of Georgia Coastal Plain Experiment Station, Tifton, GA 31793-0748

Five years of testing found equal damage on peaches from trees sprayed with an air-blast sprayer or with a PASS. A PASS is a modified boom sprayer mounted on the lower truss of a center-pivot. A PASS and an air-blast sprayer apply the same chemical formulations at the same rates per ha. Because a PASS injects no chemicals into the center-pivot, it is not chemigation. Unlike an air-blast sprayer that sprays out and up, a PASS sprays down, which should result in less spray drift. Because a PASS sprays over the tops of the trees, it places no restriction on row or tree spacing. Also, a PASS eliminates the pesticide exposure of a tractor driver spraying with an air-blast sprayer. Comparing capital costs of a PASS and an air-blast sprayer showed projected savings for the PASS of from $128/ha to over $248/ha as the orchard size increased from 7 ha to 29 ha. A PASS is much simpler than an air-blast sprayer which is pulled by a tractor, so the operating and maintenance costs for a PASS should be lower.

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DEVELOPMENT OF A SEED BIOASSAY FOR THE STUDY OF THE ALLELOPATHIC POTENTIAL OF LYCOPERSICON HIRSUTUM.

Eric B. Bish*, Thomas A. Bewick, and Donn G. Shilling[1] Horticultural Sciences Department and [1]Agronomy Department, University of Florida, Gainesville, FL 32611.

A seed bioassay was developed in order to elucidate the mechanism of interference in Lycopersicon hirsutum. Extracts of L. hirsutum were compared to extracts of other plant species, several of which have been determined to demonstrate allelopathic properties. Measurements of germination, root growth, and hypocotyl elongation were used as parameters for these experiments. A titration experiment was conducted to determine the concentrations needed for seed inhibition. $I_{50}$ values were generated to determine the concentration needed to inhibit 50 percent of the seeds for each species. L. hirsutum possessed a significantly greater inhibition than any of the other species examined. Lettuce (Lactuca sativa) and common purslane (Portulaca oleracea) seeds provided the best response because of quick uniform germination.

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CUTICULAR MEMBRANE FORMATION AND OCCURRENCE OF BUNCH ROT (*BOTRYTIS CINEREA* PERS.:FR.) WITH 3 *VITIS VINIFERA* L. CULTIVARS.

David C. Percival[1], K. Helen Fisher[2], and J. Alan Sullivan[1]
[1]Dept. of Hort. Sci., University of Guelph, Guelph, Ontario, Canada. N1G 2W1.
[2]Hort. Res. Inst. of Ontario, Vineland Station, Ontario, Canada. LOR 2E0.

Leaf removal treatments were applied to Riesling during 1990 and 1991, and to Cabernet Franc and Optima in 1991. Clusters were sampled to examine the effect of berry exposure, berry contact, time of sampling, and cultivar on cuticular membrane formation and the occurrence of bunch rot (*Botrytis cinerea* Pers.:Fr.). Non-contact and contact cuticle proper and epicuticular wax berry samples were examined qualitatively using cryogenic scanning electron microscopy and quantitatively using enzymatic separation and chloroform extraction.

Exposed Riesling samples had 18.6% and 35.0% more epicuticular wax and cuticle proper respectively than shaded samples. Non-contact Riesling samples had 15.7% and 35% more epicuticular wax and cuticle proper than contact samples, and although significant, epicuticular wax and cuticle proper weights of Riesling increased by only 5.7% and 4.5% respectively, between veraison and harvest. Although exposed cuticular membrane samples from all 3 cultivars had more epicuticular wax and cuticle proper than shaded samples, large differences between cultivars were present. Clusters from the hand leaf removal (i.e. exposed) treatment of all 3 cultivars examined had significantly less bunch rot than clusters from the control (i.e. shaded). Cabernet Franc was the most tolerant and Optima the most susceptible of the 3 cultivars to bunch rot. Time of sampling and differences between years also influenced the occurrence of bunch rot for Riesling with less rot present at veraison compared to harvest and less rot present at the 1990 compared to the 1991 harvest. Exposure, cultivar and level of contact within the cluster are all important factors in the cuticular membrane formation process and contribute greatly to the overall susceptibility of a grape cultivar to bunch rot when grown in a temperate climate.

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SWEETPOTATO LATEX: EFFECT ON SWEETPOTATO WEEVIL FEEDING AND OVIPOSITION

Stanley J. Kays[1] and Emma S. Data[2] [1]Department of Horticulture, The University of Georgia, Athens, Georgia, [2]Philippine Root Crop Research and Training Center, ViSCA, Baybay, Leyte.

Latex is known to act as a natural defense system in some laticiferous plants against certain herbivores. The importance of latex produced by the sweetpotato, *Ipomoea batatas*, Lam., as a defense mechanism against the sweetpotato weevil, *Cylas formicarius elegantulus* (Summers) (Coleoptera: Curculionidae), was tested. Distinct genetic and environmental differences were found in latex production in a broad cross-section of sweetpotato germplasm (96 lines). Most lines produced 2.6 to 10 mg fwt·vine$^{-1}$ of latex when the second internode from the apex was severed. Some lines, however, produced substantially more, the highest being 48.3 mg·vine$^{-1}$. The percent dwt of the latex exudate ranged from 2.5 to 54, with most lines falling within the 10 to 22.5% range. The amount of latex (fwt) released varied (1.9X) with differing environmental conditions (primarily light intensity). Young vine material produced more latex and had less feeding by the weevil than in older more mature portions of the vine. Application of latex to the surface of root cores markedly reduced feeding (67%) and oviposition (92%) after 24 hours in choice and oviposition in no choice experiments. Addition of latex to a semi-artificial media also significantly reduced feeding. Leaf feeding location (veins) and direction (basipetal), however, were not indicative of a deterrent role for latex. Collectively, existing evidence does not support a significant deterrent role for latex with regard to the sweetpotato weevil, however, additional information is needed on latex chemistry and quantitative and qualitative variation in latex within the sweetpotato genepool.

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IDENTIFICATION OF GRAPEVINE FANLEAF VIRUS IN XINJIAN

Liu Xueduan*, Department of Plant Protection, Hunan Agricultural College, Changsha 410128, China, Yin Yuqi, Cui Xinmin, Shinezi Agricukural College, Xinjian, China

A isolate from vineof Vitis vinifera cv. Monukka with fanleaf-like symptoms in Xinjian was obtained and studied. It infected Chenondium quinoa, C. amaranticolor, Gomphrena globosa, Cucumis sative, Nicotana clevelandii. The virus is isometrieal spherical particle of 30nm in dianeter. In the double diffusion test in agar and the indexing of immunosorbent electron microscopy(ISEM), it gave positime reaction with GFV antiserm. The virus was propagated on C. quinoa and purified by using Chloroform-Butanol + PEG(M. wt.6000), differental centrifugation and sucroses density gradient cetrifugation. The virus particle contains a protein subunit of M.wt. 56234D. and be composed of 17 species 461 acides. On the results above, the isolate was identified as Grapevine Fanleaf Virus(GFV).

# 116 ORAL SESSION 27 (Abstr. 230–235) Vegetable Crops: Culture and Management III

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YIELD OF WATERMELON AS INFLUENCED BY PLANT SPACING

D. Scott NeSmith, The University of Georgia, Department of Horticulture, Georgia Experiment Station, Griffin, GA 30223

Watermelon (*Citrullus lanatus* (Thunb.) Matsum & Nakai) cultivars Starbrite and Crimson Sweet were grown during 1991 and 1992 in 1.5 m wide rows at plant spacings of 0.9 m, 1.5 m, or 2.2 m. Total fruit yield, marketable fruit yield, fruit size distribution, and estimated gross returns were determined for the different spacing treatments. Total and marketable fruit yields were greater overall for 'Starbrite' than for 'Crimson Sweet'. With the exception of 1991 'Crimson Sweet' yields, marketable fruit yields per unit land area increased 29% to 34% as plant spacing was decreased from 2.2 m to 0.9 m. The yield component contributing the most to increased yields with higher density plantings was increased fruit number per unit land area. Average fruit weight responded only slightly to decreased plant spacing. Fruit size distribution on a relative frequency scale was stable regardless of plant spacing or production year. The potential for increasing gross returns per unit land area exists by increasing watermelon plant populations beyond the current Georgia recommendation of 2500 to 3000 plants ha$^{-1}$.



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WATERMELON PRODUCTION SYSTEM INFLUENCES YIELD AND QUALITY

Jonathan R. Schultheis*, Douglas C. Sanders and David W. Monks
Dept. of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

The watermelon variety 'Sangria', commonly grown in the eastern United States, has a tendency to produce off-shaped fruit. Certain watermelon varieties may require specific cultural practices to maximize both yield and quality. The objective of this study was to compare various production systems and varieties, and to evaluate their effects on fruit yield and quality. In 1991 and 1992, the effects of irrigation (overhead, drip or natural rainfall), with and without plastic on earliness, fruit quality and yield were evaluated on 'Crimson Sweet', 'Regency', 'Royal Jubilee' and 'Sangria'. In 1991, the best yield was obtained when black plastic mulch and drip irrigation were both used, while greater yields in 1992 were obtained when plastic was used with either overhead or drip irrigation. A higher percentage of melons were marketable with drip or overhead irrigation compared with non-irrigated plots. Less marketable melons were obtained with 'Sangria' and 'Crimson Sweet' in 1992. An earlier harvest was obtained with plastic mulch in 1992. 'Royal Jubilee' was the best yielding variety.

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TRIPLOID WATERMELON YIELD AND QUALITY COMPONENTS

Carl E. Motsenbocker* and David H. Picha, Dept. of Horticulture, LSU Agricultural Center, Baton Rouge, LA 70803

Twenty-seven triploid watermelon cultivars and/or breeding lines were evaluated for yield and quality components. Total yield, rind thickness, mature and immature seed count, incidence of hollow heart, soluble solids, sugars, pH, titratable acidity, and internal color were measured for each cultivar/breeding line. Yields ranged from 32,000 to 66,000 kg per hectare. 'Jack of Hearts' was the highest yielding cultivar. Hollow heart was moderate to severe in five of the genotypes. Except for two breeding lines, soluble solids were at least 11 per cent. Rind thickness ranged from 15.0 to 22.2 mm. Little or no mature seed was present in most of the genotypes. The cultivar 'Millionaire' and the CLF breeding lines, with the exception of CLF 1016, contained the most mature seeds. A range of internal color and individual sugar content (fructose, glucose, sucrose) existed between genotypes.

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DRIP IRRIGATION RATES AFFECT WATERMELON YIELD

Donald N. Maynard* and Gary A. Clark, University of Florida, 5007 60th St. E., Bradenton, FL 34203.

'Crimson Sweet', 'Jack of Hearts', 'Mickylee', 'Royal Jubilee', and 'Sangria' watermelon transplants were set in raised, fumigated, 61-cm wide polyethylene-mulched beds with previously installed drip irrigation tubing (Roberts Ro-Drip) with 30-cm emitter spacing and 6.25 liter·min$^{-1}$·100 m$^{-1}$ nominal discharge in the spring 1992 season. After a 14-day crop establishment period, variable irrigation rates based on ratios of calculated Penman reference ET$_o$ were used. For the remainder of the season, 96, 185, or 300 mm of irrigation were applied. Highest yields and average fruit weight were produced by 'Royal Jubilee'. Highest soluble solids and frequency and severity of hollowheart were produced by 'Jack of Hearts'. Except for 'Royal Jubilee', there was a quadratic yield response to irrigation rate for the other varieties.

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MINI WATERMELON MARKETING AND DRIP IRRIGATION STUDY

D. C. Sanders*, K. A. Bailey, D. E. Adams, J. R. Schultheis and E. A. Estes, Departments of Horticultural Science and Agriculture and Resource Economics, North Carolina State University, Raleigh, NC 27695

'Tiger Baby' mini watermelons were direct seeded into black plastic mulch with drip fertigation irrigation. Drip lines were run for 300 m feet, in excess of that recommended. Single plants were 45 cm apart in 1.5 m rows. Yields were taken from the total 300 m and from the first 90 m of row. Yields only slightly affected by drip tubing type. We also conducted a marketing test with these watermelons. Boxes of 9 melons each (2.5-3.6 kg) were sold at 'upscale' grocery chain. Produce managers and customers were surveyed. Size seemed to be the most important selling point, followed by taste. Sales increased once the manager cut a sample melon. In general 40% of the melons sold in the first week and the remaining 60% the second week. Prices averaged $2.00 and minimelons competed favorably with standard sizes.

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*EFFECTS OF SPACING AND IRRIGATION REGIME ON THE PRODUCTION OF WATERMELONS FOR SEED CONSUMPTION*

*Haim Nerson* and Yosef Burger, Department of Vegetable Crops, A.R.O., Newe Ya'ar Research Center, P. O. Haifa, Israel*

*Two field experiments were conducted at Newe Ya'ar (northern Israel) to examine the effects of spacing and irrigation on the production of watermelons for seed consumption. Increasing population from 3000 to 12000 plants/ha significantly increased fruit number per unit area and only slightly decreased mean fruit weight. Increasing the water supply from dryland farming to weekly irrigation significantly increased mean fruit weight but had only a small effect on fruit number. Seed yield positively correlated with fruit number per unit area and to a lesser extent with fruit yield. In 1991, maximal seed yield (1.33 kg/10 m$^2$) was obtained in the higher population density (10,000 plants/ha) supplied with one irrigation (800 m$^3$/ha) at fruit set. In 1992, maximal seed yield (1.24 kg/10 m$^2$) was obtained in the highest population density (12,000 plants/ha) supplied with weekly irrigation. Mean seed weight was not affected significantly by spacing or irrigation regime, nor by fruit size or fruit number per unit area. Yellow Malali, derived by selection in a commercial field, had twice the seed yield as the commercial cultivar Malali.*

## 117 ORAL SESSION 28 (Abstr. 236–241) Fruit Crops: Photosynthesis

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WHOLE-TREE GAS EXCHANGE, MITE DAMAGE, AND FRUIT DEVELOPMENT IN APPLE.

Alan N. Lakso*, Giovan Battista Mattii, Jan P. Nyrop and Steven S. Denning, Departments of Horticultural Sciences and Entomology, NY Agricultural Experiment Station, Geneva, NY 14456 USA and Dipartimento di Ortoflorofrutticoltura, Universita di Firenze, ITALY

This study examined the hypothesis that late-season European Red Mite (ERM) injury effects on fruit development are mediated via carbon relations of apple trees. ERM injury were allowed to develop in mature semi-dwarf 'Starkrimson Delicious'/M26 trees with moderate crops (about 30 t/ha). Populations of ERM developed concurrently in all trees, but were controlled with miticides at different mite-day levels, giving a range of final mite-days from 300 to 2100 on individual trees as estimated by weekly leaf sampling for mites. At intervals through the season fruit growth was monitored. Diurnal whole tree photosynthesis was measured with eight clear flexible "balloon" whole tree chambers. Before the mite injury developed, fruit sizes were very similar, but in the last 60 days before harvest differences in fruit weights of up to about 50 grams were induced by mite injury which reduced whole tree photosynthesis comparably. The final fruit growth and size were well correlated with whole tree photosynthesis per fruit. Effects on other fruit quality factors were minor. These results suupport the hypothesis that whole tree source/sink balance may be an integrator of crop load and mite injury effects on fruit development. Fruit growth rates may be a practical monitor of the integrated effects of crop load and stresses.



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**NET $CO_2$ ASSIMILATION RESPONSE OF APPLE TO TEMPERATURE UNDER FIELD CONDITIONS**

Renae E. Moran*, Curt R. Rom and Andy Mauromoustakos, Depts. of Horticulture and Forestry, and Agricultural Statistics, University of Arkansas, Fayetteville, AR 72701.

**Temperature is an important factor determining net $CO_2$ assimilation (A). The reported optimum temperature for A in apple (Malus x domestic, Borkh.) under controlled conditions is between 16-30C. Response of A to temperature as it occurs in the field was measured with an open system IRGA for both spur and shoot leaves during 12 days from April through August of 1992. Trees studied were 11-year-old *'Golden Delicious'*, *'Spartan'* and *'Newred Jonathan'* on M.7a trained to a three wire trellis. Response to temperature from 17-36C was quadratic for both spur and shoot leaves, but at each temperature A varied by about 10 $\mu mol.m^{-2}.s^{-1}$. Part of the variation was attributed to varying ambient $[CO_2]$ which varied from 321 to 396 ppm, depending on date of measurement. Covariate analysis using $[CO_2]$ as the covariate was conducted. Thus, the A model of temperature response takes into account $[CO_2]$. The data will be discussed in view of interpreting plant response in the field and inherent problems with measuring A in situ.**

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WHEN DOES PHOTOSYNTHESIS LIMIT YIELD OF PEACH?

M. Catania and J. A. Flore,* Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325.

Terbacil (100 ppm) was applied to mature Redhaven (Prunus persica L. Batsch), once, or twice in different combinations during stage I, II, or III of fruit development or after harvest to determine the effect of photosynthetic inhibition on abscission, fruit size, yield, and shoot growth of the current seasons crop, and winter hardiness, tree carbohydrate status, and return bloom and fruit set the following year. Following application all trees were thinned to the same level in the middle of stage II. Field determinations indicated terbacil inhibited photosynthesis to 0-20% of the control within 24 h, and that leaves recovered to 85-95% within 7-10 days. Fruit thinning was related to the time of application, however, there were no significant differences in crop load at harvest. Fruit size, yield and maturity were inversely related to the time of application. Cold hardiness of the shoots was reduced significantly by Nov. 30 for all applications. Carbohydrate and 1993 fruit set analysis are incomplete at this time. This study indicates that stress early in the season has a greater effect on the current season crop than a similar stress later in the season.

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**CYCLES IN GAS EXCHANGE OF PEACH IN GREENHOUSE.**

Umedi L. Yadava*, Agricultural Research Station, School of Agriculture, Fort Valley State College, Fort Valley, GA 31030-3298

Observations from the field experiments on peach (*Prunus persica*) over the past 7 years suggested a possibility of regular cycles in single leaf gas exchanges (SLGE). The purpose of this research was to study SLGE of peach under the controlled photosynthetic light using metal halide lamps in the greenhouse to determine if such cycle existed. Eighteen trees of Redhaven peach, 6 each on Lovell, Nemaguard, and Wildpeach rootstocks grown in 30 L plastic containers, which were arranged on 2 benches 6 feet below the metal halide lamps. Two leaves per tree were selected 5 feet below the individually controlled lamps. Lights were turned on 30 minutes prior to observations for PAR, leaf temperature, transpiration, stomatal conductance, and photosynthesis measurements. Using a portable (LI-6000) photosynthesis system, SLGE were recorded on the same leaves daily from 0900 to 1100 h for 3 weeks starting on 1 July 1992. Though fluctuating natural light caused minor variations in PAR, it was always above the saturation point. Light did not affect leaf temperature. No distinct cyclic pattern for any of the measured SLGE parameters was observed. Rootstock significantly affected photosynthesis; trees budded on Lovell had higher rate than on Wildpeach. It is concluded that the likely cycles in the SLGE data from field studies may not be real but have resulted from the environment.

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PHOTOSYNTHETIC AND GROWTH RESPONSES TO CANOPY MANIPULATION OF 'TITAN' RED RASPBERRY

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

It has been suggested that in red raspberry, primocanes and floricanes compete with one another for light and/or photosynthetic products, under most management systems. In 1991, a field study was initiated to determine the effects that altering this natural balance between primocanes and floricanes would have on leaf photosynthetic rates and growth components. Fourteen treatments were applied to a mature planting of 'Titan' red raspberry in the spring of 1991. Treatments included partial or entire canopy shading and/or removal of primocanes, floricanes or fruit. All treatments were removed at the end of the 1991 growing season. Photosynthetic and growth data were collected over a two-year period. Both shading and removal of growth had profound effects on data in both years. In general, removal of primocanes floricanes or fruit enhanced growth of the remaining form(s) of growth. However, this effect was negated if all or part of the canopy was shaded. Floricane photosynthesis was highest in the presence of fruit preceding and during harvest. Treatments had an effect on primocane photosynthetic rate only after fruiting. In 1992, shading treatments applied the previous year resulted in lower primocane photosynthetic rates than those treatments which were not shaded. The data generated from this study will help us describe the complex relationship between primocanes and floricanes.

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ESTIMATION OF STRAWBERRY LEAF CHLOROPHYLL CONTENT AND PHOTOSYNTHETIC ACTIVITY USING REFLECTANCE AND FLUORESCENCE MEASUREMENTS IN THE FIELD

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

Portable spectroscopy and fluorescence instruments were used to establish a nondestructive method for estimating chlorophyll (Chl) content and photosynthetic activity in strawberry leaves. 25 genotypes of *Fragaria chiloensis* were selected as experimental material from a large, replicated field collection. Gas exchange, Chl content, leaf reflectance spectra and induction kinetics of fluorescence from dark-adapted leaves were measured in newly expanded mature leaves.

Negative correlation coefficients between reflectance measurements at 510-650 nm and 690-700 nm and Chl a, b and total Chl were highly significant and reached their peak values around 570 nm ($r=-0.80^{**}$, total Chl). Multiple regression analysis showed that combining the reflectance measurements at 520 nm with 570 nm significantly improved the model's correlation coefficient ($r=0.86^{***}$, total Chl). Reflectance at 520 and 570 seems to represent signals from different components in the photosynthetic apparatus. Combining certain fluorescence parameters with reflectance measurements significantly improved the correlation with Chl a, b and total Chl ($r=0.91^{***}$, total Chl). The regression model combining reflectance and fluorescence measurements offers a useful, nondestructive method to simultaneously assess leaf Chl content and induction kinetics of fluorescence using portable spectroscopy and fluorescence instruments. Fluorescence parameters $F_v/F_m$ and $F_t$ combined to show a moderate relationship ($r=0.66^{**}$) with $CO_2$ assimilation rate.

## 118 ORAL SESSION 29 (Abstr. 242–246) Woody Ornamentals/Landscape: Extension/ Education

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ADVENTURES IN BROADCASTING: TEACHING LANDSCAPE MANAGEMENT BY SATELLITE

L. A. Rupp*, R. Kjelgren, and R. E. Lindsay. Dept. Plant, Soils, and Biometeorology, Utah State Univ., Logan UT 84322; W. E. Johnson. Dept. Agr. Economics, Univ. of Nevada, Reno NV 89557

The AG*SAT network is designed to allow sharing of instructional resources by broadcasting courses among peer institutions. In the fall of 1992 we taught the course "Landscape Management in the Interior West" by satellite over AG*SAT to students in Utah, Nevada, Nebraska, and Idaho, and on the Utah State University campus. Impetus for the course was to address the unique landscape needs of a region with few formal horticultural programs. The broadcast originated from an on-campus studio without students present, but with a two-way audio link. We encountered several unforeseen challenges during course preparation. It required a substantial time investment of approximately four hours for every hour of instruction. Marketing among peer institutions required a three-tiered consensus among faculty, deans of instruction, and telecommunication services. The initiative of peer faculty was very helpful in achieving this consensus. We were more successful in bringing the course to extension offices than to campuses. Student response varied with location and degree of involvement. On-campus students were critical of a perceived lack of face-to-face contact with faculty. Positive responses came from viewers in remote locations where access to college-level courses is otherwise limited. In lieu of personal interaction, videos and very detailed written support materials were critical in eliciting student involvement.

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**INITIATING A STATEWIDE CERTIFICATION PROGRAM FOR LANDSCAPE PROFESSIONALS**

**Gary L. Wade, Horticulture Department, The University of Georgia, Athens, GA 30602**

Other than short courses and one-day seminars offered by Universities and Technical schools, there has not been a vehicle in Georgia specifically designed to certify professional competence in the landscape industry. With a grant from the Georgia Green Industry Association a statewide certification program was developed. A 200-page study manual was developed along with a practical hands-on exam. The landscape certification exam requires seven hours to administer and involves four written components and nine practical components. The written components examine a participant's general knowledge, his ability to read and interpret a landscape plan, his ability to identify common landscape pests, and his ability to select plants properly for various site situations. The practical component of the exam, administered in an outdoor setting, requires a participant to demonstrate such skills as grading, pruning, sod installation, planting, staking trees, pesticide application, and equipment operation and maintenance. Two permanent testing sites, one in the northern part of the state and one in the southern part of the state, are presently being established. The exam is administered by the Landscape Division of the Georgia Green Industry Association.

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LIMITED-SCOPE AUTOCAD® SELF INSTRUCTION FOR BASIC LANDSCAPE DESIGN

Paul A. Swanberg* and Margaret Balbach, Industrial Tech. Dept. and Agriculture Dept., Illinois State University, Normal, IL 61761-6901

Many students in landscape design courses do not have experience in use of the computer for drafting designs. University and college situations, where computer laboratories may have only AutoCAD® installed on the computers, present an obstacle to horticulture students in that CAD courses are not ideally suited to their specific needs, and also require considerable time in doing the typical CAD assignments. Yet, if students could graduate with some basic experience in the application of AutoCAD® to landscape design drafting, they would be better equipped to meet employer needs for personnel prepared to handle computer drafting. A self-paced training manual with an embedded tutorial program has been developed with exercises that introduce the student to the basic commands and capabilities of AutoCAD®. This program takes the student through application of these commands to a landscape design layout. It contains a library of plant symbols and allows the student to design new symbols. The program also gives the student the ability to generate a materials and price report for every design generated.

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THE WOODLAND VEGETATION OF STEPHEN F. AUSTIN STATE UNIVERSITY REVISITED: A CAD\GIS ANALYSIS

D. Creech*, J. Singhurst, D. Kulhavy, G. Seibel, and D. McDonald, Department of Agriculture and College of Forestry, Stephen F. Austin State University, Nacogdoches, TX 75962

Urban landscape ecology is a new interest that crosses several disciplines: botany, forestry, horticulture, sociology and land use planning. University forest environs are often the most degraded; foot traffic, development and a shortage of funds for significant tree plantings are main culprits. SFASU lies in the pineywoods region of east Texas and is known as the "university among the pines." The campus is blessed with many patriarch pines and hardwoods. Computer-assisted drafting (CAD) and Geographic Information Systems(GIS) platforms are being utilized to map the campus vegetation. A 1992 vegetative analysis, when compared to similar studies in 1971 and 1983, indicates a loss in species diversity and frequency with little change in basal area. AutoCad®, LandCadd®, and Studio-3D® are being integrated into a multi-disciplinary project to develop a three-dimensional biotic/abiotic model of the campus. That model will be used as a "fly-through" visualization tool to develop forest conservation strategies most likely to succeed in a sustainable fashion.

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A GRAPHICAL INTERFACE FOR MAINTAINING PLANT ACCESSION AND DATA RECORDS IN dBASE IV

Douglas C Needham, Assistant Professor of Floriculture, Oklahoma State University, Department of Horticulture and Landscape Architecture, 360 Agricultural Hall, Stillwater, OK 74078-0511.

The Oklahoma Botanical Garden and Arboretum (OBGA) at Oklahoma State University was awarded an "America the Beautiful" grant from the Oklahoma Department of Agriculture and the Oklahoma Urban and Community Forestry Council to develop a plant database and plant identification labels.

The OBGA Plant Information Manager version 1.0 was created to assist students, volunteers, and staff of public gardens with maintenance of data from plant accession, growth, flowering, fruiting, etc. The program is a graphical interface to dBASE IV records, created with Borland's ObjectVision 2.0 for Windows.

Users are prompted for information via "check boxes" ☒, "radio buttons" ◉, and selection lists, thereby reducing incorrect entries. The series of forms leads the user through the process of plant accessioning, including information on donor, size, flowering season, fall foliage color, planting site, cultural preferences, etc.

## 119 ORAL SESSION 30 (Abstr. 247–251) Floriculture: Breeding and Genetics

247
MORPHOLOGICAL VARIATION IN A PETUNIA GERMPLASM COLLECTION

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

In 1992 a petunia breeding program was initiated at the University of Georgia. The objective of this particular study was to screen an extensive collection of petunia germplasm for variability of numerous vegetative and floral characters in order to determine sources and extent of morphological variability existing in petunia.

One hundred twenty-two petunia cultivars and accessions including 83 current commercial $F_1$ cultivars, 24 older cultivars, 3 accessions of the putative progenitor species of *Petunia hybrida*, 1 open-pollinated reseeding line, and 11 inbred lines were measured for 9 vegetative and floral characters. Genotypes include selections from all countries with major petunia breeding programs. Plants were grown in the greenhouse and measurements taken at time of first bloom.

Analysis of variance revealed highly significant variation among genotypes for each of the 9 characters measured. Cluster analysis was utilized to examine relationships among genotypes and to identify unique genotypes that may be useful in the UGA petunia breeding program.

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DNA AMPLIFICATION FINGERPRINTING OF *PETUNIA* SPECIES

Teresa A. Cerny* and Terri W. Starman, Dept. of Ornamental Horticulture & Landscape Design, University of Tennessee, Knoxville, TN 37901-1071

Earlier research suggests that *P. axillaris*, *P. inflata*, *P. parodii*, and *P. violaceae* may be part of the evolution of *P.* X *hybrida*. The precise probe and endonuclease combinations which would distinguish between these closely related species has not been found using other methods of DNA fingerprinting. Knowledge of the relationships among species within this genus could serve to advance breeding of *P.* X *hybrida*. The objectives of this project were to use DNA amplification fingerprinting (DAF) to fingerprint *P.* X *hybrida* and the four previously discussed species to show differences between them and to demonstrate the utility of DAF for floricultural crops. DAF does not require a precise probe; instead, it uses short arbitrary primers. Petunia seeds were obtained from foreign sources. Seedlings were grown in 0.4-liter plastic pots containing soilless medium under glass greenhouse conditions of 24/18°C. Tissue samples were collected, frozen with liquid nitrogen and stored in an ultra-low freezer. DNA was isolated and then amplified. Six different primers were used throughout the research. By using different primers, different segments of the DNA were amplified so more information about the relationships between species could be gained. Gels were both visually examined and quantitatively analyzed by a densitometer. Primer sequences GA-AAC-GCC and GT-TAC-GCC were found to be the most effective in showing amplification fragment length polymorphisms. Distinct differences were found between each of the species.



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VARIATION IN MALE FERTILITY OF *PELARGONIUM XDOMESTICUM*

Mary Stuart*, Glenn Haniford and Pablo Jourdan, The Ohio State University, 2001 Fyffe Court, Columbus, OH, 43210

Poor seed set in *P. xdomesticum* hinders development of new and improved cultivars. Crossing data has indicated differences among selections in male fertility. A study was undertaken to examine the amount of male fertility in the species as evidenced by pollen staining and pollen germination and development. Eight *P. xdomesticum* selections were crossed as males onto two selections used as females. 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 produced in the style. Pollen from the 8 selections was tested for viability by staining with fluorescein diacetate (FDA) and examined using fluorescence microscopy. The males varied in pollen viability from 69% pollen staining producing 16 pollen tubes to 18% saining producing 3 tubes. The most fertile males produce enough pollen tubes to effect fertilization of all of the ovules in a *P. xdomesticum* ovary.

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RECURRENT SELECTION FOR FLOWER COLOR IN THE DAVIS POPULATION OF GERBERA

Kenneth R. Tourjee*, James Harding, Thomas G. Byrne Environmental Hort. Dept. University of California, Davis, CA 95616

Flower color can be treated as a composite of three quantitative traits. The traits hue (H), chroma (C), and value (L), as described in the CIELAB (1976) color system, are continuous variables easily included into an index of a recurrent selection program. A Euclidian distance index was utilized to minimize the mean distance of a population to a color point (dark yellow). The index was:

I= sqrt[0.5*(H-85)**2 + 0.25*(C-80)**2 + 0.25*(L-50)**2]

The index was applied to generation 15 of the Davis Pop. of gerbera, and two cycles of selection were performed (sel. intensity= 2.3 and 2.0 respectively). Crosses were made via a 6x6 factorial mating design. The mean index score in gen. 15 was 38.57 . Two cycles of selection changed the mean to 15.08 . The N.S. heritabilities for H, C, and L in gen. 15 were 0.6, 0.7, and 1.0 . Selection reduced the heritabilities to 0.2, 0.0, and 0.1, respectively. The add. genetic corr. between H & C, H & L, and L & C were 0.1, 0.8, and -0.5, respectively. After selection, the correlations were 0.7, 0.9, and 0.2, respectively.

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DIFFERENTIAL GENE EXPRESSION DURING VERNALIZATION FOR FLORAL INDUCTION OF *RAPHANUS SATIVA*

Mark S. Strefeler*, John E. Erwin and Gerald Pierson, University of Minnesota, Department of Horticultural Science, 305 Alderman Hall, 1970 Folwell Avenue, St. Paul, MN 55108

Previous studies on low temperature induction of flowering in Japanese radish, *Raphanus sativa* L., revealed that 'Chinese Radish Jumbo Scarlet' was a cold obligate cultivar. 'Chinese Radish Jumbo Scarlet' responded quantitatively to the number of days exposed to vernalizing temperatures (6 C). Fifteen percent of the plants were induced to flower when exposed to 6 C for 5 days. This response increased proportionally to 100% induction when plants were vernalized at 6 C for 30 days. This type of response allowed us to examine the changes in gene expression over time during the vernalization process.

cDNA libraries were constructed from non-vernalized radish seedlings and seedlings vernalized for 1, 5, 15 or 30 days. Differential screening of the cDNA libraries was carried out to determine changes in gene expression related to the vernalization or induction processes. Up and down regulation of gene expression and activation or deactivation of genes during the vernalization process will be discussed. The ultimate goal of this project is to elucidate the processes involved in floral induction and how these processes are initiated by exposure of plants to vernalizing temperatures.

# 120 ORAL SESSION 31 (Abstr. 252–258) Fruits: Substropical/Tropical

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METHODS TO RECOVER TRIPLOID CITRUS HYBRIDS FOLLOWING 2x X 4x HYBRIDIZATION

Y. Jia* and F. G. Gmitter, Jr., University of Florida, Citrus Research and Education Center, 700 Expt. Sta. Rd., Lake Alfred, FL 33850

Methods for production of *Citrus* triploids were investigated. Ten diploid, strictly zygotic clones were used as seed parents. Two tetraploid somatic hybrids ['Key' lime (*Citrus aurantifolia)* with 'Valencia' sweet orange (*C. sinensis)*, and 'Hamlin' sweet orange with 'Flying Dragon' trifoliate orange (*Poncirus trifoliata)*] and two autotetraploids were used as the male parents. Embryos were excised from underdeveloped seeds 3-6 months after pollination and cultured. Murashige and Tucker's medium was supplemented with either malt extract (500 $mg \cdot L^{-1}$) and adenine sulfate (25 $mg \cdot L^{-1}$) (EMA), with gibberellic acid (1 $mg \cdot L^{-1}$) (EG1), or with malt extract (1500 $mg \cdot L^{-1}$) (MTG). Embryo proliferation was observed from 11.5% of all cultured embryos excised 3-4 months after pollination, but varied among crosses. Ploidy level was determined by flow cytometry. Most recovered plants were triploid, but tetraploids and diploids were also identified at frequencies that varied among crosses. The greatest frequency of 3x plant recovery per embryo rescued resulted when embryos were harvested 3 months post-pollination and cultured on EG1 medium.

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TRANSMISSION OF CITRUS TRISTEZA VIRUS RESISTANCE FROM CITRUS BREEDING LINE US119

C. Jack Hearn,* Stephen M. Garnsey, and Herbert C. Barrett, USDA, ARS, USHRL, 2120 Camden Road, Orlando, FL 32803.

Citrus rootstocks resistant to decline induced by citrus tristeza (CTV) have been developed using resistance found in *Poncirus trifoliata* (L.) Raf. A breeding line with resistance to CTV infection, US119 [*Citrus paradisi* Macf. cv. Duncan x *P. trifoliata* (L.) Raf. x *C. sinensis* cv. Succory], was developed and crossed with 'Ambersweet' orange [*C. reticulata* Blanco x (*C. paradisi* x *C. reticulata*) x *C. sinensis*] to develop scions resistant to CTV infection. Fifty-one progeny were tested for CTV resistance by grafting each to rough lemon [*C. limon* (L.) Burm. f.] seedlings infected with CTV. These propagations were assayed repeatedly by ELISA. Seventeen progeny consistently tested negative for CTV (resistant), 24 were consistently positive (susceptible), and 10 gave weak or inconsistent reactions. These results confirm the feasibility of developing CTV-resistant scions by use of US119 to solve the stem pitting disease caused by CTV.

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ALLOZYME DIVERSITY IN THEOBROMA CACAO

C.M. Ronning* and R.J. Schnell, USDA-ARS Subtropical Horticulture Research Station, Miami, FL, 33158.

Theobroma cacao is a morphologically diverse species. To understand variation within species, gene diversity estimates for a germplasm collection were calculated from allozyme data. Of nine enzymes assayed, six enzymes encoded by nine loci were found to be polymorphic. The population was subdivided into subpopulations in two ways: by geographical origin and by morphological type. Total gene diversity was similar to that of other tropical, outcrossing, perennial species. Most of this diversity was found within, rather than between, subpopulations; the differentiation was higher among types than among origins. Caribbean and Central American clones were more closely related to each other, and distinct from, South American clones. Two clusters were formed when grouped by type: Trinitario/Criollo and Forastero/intergroup hybrids. This information may be useful to the breeder, as well as for the maintenance of genetic diversity within a germplasm collection.



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GENETIC VARIATION IN *CARICA PAPAYA* GERMPLASM

Maimunah Morshidi[1]*, Richard M. Manshardt[1] and Francis Zee[2], [1]Department of Horticulture, University of Hawaii, Honolulu, HI 96822, [2]USDA-ARS, P.O.Box 4487, Hilo, HI 96720

Genetic variation was examined by multivariate analysis among cultivated and wild *Carica papaya* from five Central American countries (Mexico, Belize, Guatemala, Honduras, and Costa Rica), together with cultivated materials from Malaysia, Thailand, Hawaii and South America (Venezuela and Peru) based on allele frequencies in each country. Five seedlings from each accession were analyzed for isozyme variability using starch gel electrophoresis. Aconitase (ACO), isocitrate dehydrogenase (IDH), malate dehydrogenase (MDH), phosphoglucoisomerase (PGI), phosphoglucomutase (PGM), triosephosphate isomerase (TPI) and alcohol dehydrogenase (ADH) gave consistent and polymorphic banding patterns. Cluster and principal component analyses indicated that materials outside of Central America differed from those in Central American countries due to the presence of wild papaya accessions in Central America.

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MULTIYEAR PRODUCTION CYCLES OF VALENCIA ORANGE SOLUBLE SOLIDS PER FRESH WEIGHT COINCIDE WITH EL NINO EVENTS

L. Gene Albrigo, Citrus Research and Education Center IFAS, University of Florida, Lake Alfred, FL 33850

Using fruit yield, fruit quality and weather data summaries from Florida during the previous 25 years, this study sought correlations between climatic conditions, annual 'Valencia' orange yields and fruit quality. Soluble solids, expressed as g per kg of harvested fruit, fluctuated from 44 to 81 g per kg fresh fruit in rhythmic cycles of 3 to 5 years duration. These cycles did not relate to cycles of fruit production per tree nor to changes in average fruit size from season to season. The years with high solids appear to coincide with the warm winters of El Nino cycles and years with low solids coincide with wet winters events. Annual temperature and rainfall patterns along with possible physiological responses related to trends in production of soluble solids will be discussed.

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ANALYSIS OF HAWAII AGRICULTURE AFTER 'INIKI' HURRICANE.

'Timi Smith-Kayode* and [2]Richard Thompson. 'Agricultural inputs, trade and investment opportunities project, Institute for economic developemt and policy,East West Center. Honolulu, H196848 [2]Hawaii Pacific University, 1188.Fort St. Honolulu H196813 U.S.A.

Sustainable production system encompassing Macademia, Sugar, Coffee, Fruits and Flowers a hall mark of Hawaiian Agriculture is now threatened by hurricane and rain storms. Concerns for crop losses and set back in agribusiness are beign intensively discussed against the background of future diversifications of operation and investment.

Findings from post 'Iniki' hurricane study of losses through survey of Hawaii grown economic commodities produced on the Island of Kaui are contained in this paper.

Highlights showed that banana and papaya farming systems have the highest recovery potential. The impact on fruit processing industries is also discussed.

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INTEGRATIVE PEST MANAGEMENT IN TEA PLANTATION

Tan Jicai*, Deng-Xing, Department of Plant Protection Hunan Agricultural College, Changsha 410128, China, Qin Zunbing, Dongshanfeng State Farm, Shimen, Hunan, China.

Two major measures were practiced in Dongshanfeng State Farm in Hunan province of China from 1988-1992. a/ Plant trees and readjust structure of crops toprotect the natural enviornment and ecosystem of the tea plantation; b/ Put chemical control under ecological blance by using agricultural technical measures as the basic way and natural control of insectpest as the leading technigues. It showed the total average of poisonous element in air $SO_2$ 0.025mg/Km$^3$, $NO_x$0.009mg/Km$^3$, Tsp 0.059mg/Km$^3$; there were no-pollution in water of irrigate the fields, the tea plantation soils and the made tea; the quanting of natural enemy intea plantation were inceased It had benefited of farm greatly both in production and ecology.

## 129 ORAL SESSION 32 (Abstr. 259–266) Fruits: Plant Growth Regulators

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BLOSSOM THINNING OF 'WENATCHEE' AND 'TILTON' APRICOTS WITH AMMONIUM THIOSULPHATE

Norman E. Looney* and Michael A. Beulah, Agriculture Canada Research Station, Summerland, B.C., CANADA V0H 1Z0

A single spray of ammonium thiosulphate (ATS) fertilizer applied when the spur flowers are approaching full bloom and lateral flowers are at about 50% of full bloom effectively reduced hand-thinning time and substantially improved fruit size of apricot in experiments conducted over a four year period. When applied as a gun spray to solution run-off, 0.4% and 0.5% ATS reduced hand-thinning time by at least one-third, increased fruit size by about 20%, and did not reduce branch and tree yields compared to control trees hand-thinned at the normal time. Airblast sprays also proved effective but the amount of wetting appears to be very critical to success. With mature plantations, 1500 to 1800 L/ha of 3% ATS gave satisfactory results. Information concerning the relative susceptibility of spur and lateral flowers and beneficial effects on fruit color and internal quality will be presented and discussed.

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THINNING 'DELICIOUS' APPLE: TRIALS AND TRIBULATIONS

John C. Neilsen* and Frank G. Dennis, Jr. Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325.

Response of 'Delicious' apple to chemical thinning is often erratic. Experiments were conducted to test the effects of crop density, thinning and strain on yield and fruit size. The relationship between crop density and fruit size was determined in 3 orchards over 2 years. In one orchard the relationship was consistent in both years, but in the other two, it varied widely. Naphthaleneacetic acid (NAA) was applied to 10-year-old trees at one location in 2 successive years (1989-90). NAA treatments were compared with early hand thinning (15 days post bloom) in 1989 and with NAA plus carbarl (Sevin) in 1990. In 1989 both NAA and hand thinning reduced crop density and yield, but only hand thinning increased fruit size. No treatments applied in 1990 reduced crop density, and effects upon size and economic return were minimal. Strain differences in response to NAA and its amide (NAAm) were evaluated in 1989 and 1990. NAA (13 and 20 ppm) failed to reduce crop density in 1989, but fruit size was reduced. NAAm at 50 ppm overthinned both years, but was effective at 25 ppm in 1990. Fruit set was generally lower in non-spur than in spur strains.



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COMPARISON OF NAA AND SEVIN PETAL FALL SPRAYS ON FRUIT SET OF APPLES

Max W. Williams, USDA, Agricultural Research Service, Tree Fruit Research Laboratory, 1104 N. Western Avenue, Wenatchee, WA 98801

In Washington and other western states Elgetol, a blossom thinning agent was previously used before the postbloom NAA and Sevin applications and there was no need for an earlier timing of NAA and Sevin treatments. In 1989, Elgetol was removed from the market by the manufacturer because of minor crop use and the high cost of re-registration. Without a blossom thinner it is impossible to guarantee a return bloom on severe biennial bearing cultivars such as Golden Delicious and Fuji. Even though adequate fruit thinning occurs with the postbloom thinning sprays, flower initiation may not occur for the next years crop because the application is made too late.

NAA and Sevin are used as postbloom sprays for reducing fruit set of apples. The usual time of application is when the largest fruit are from 10 to 15 mm in diameter. Sprays applied at the 10-15 mm fruit diameter stage take advantage of warm weather after spraying which increases stress and maximizes reduction of fruit set with a minimum effect on the seed number, however, when temperature is cold seed abortion occurs without adequate reduction of fruit set.

This report compares the efficacy of the postbloom thinners NAA and Sevin as early petal fall sprays for reducing fruit number and increasing return bloom the following year. Sevin is most effective as an apple fruit abscission agent when applied at petal fall. In trials for 2 years there was no reduction in fruit seed number, no reduction in fruit size and no effect on fruit shape. In comparison NAA applied at petal fall tended to reduce seed number, reduce fruit size, flatten or distort fruit shape and cause leaf curling.

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EFFECTS OF NAPHTHALENEACETIC ACID (NAA) THINNING SPRAYS ON FRUIT SIZE OF REDCHIEF 'DELICIOUS' APPLES

Brent L. Black*, Martin J. Bukovac and Jerome Hull, Jr., Department of Horticulture, Michigan State University, East Lansing, MI 48824

NAA is commonly used for post-bloom apple thinning. However, occasionally with 'Delicious', excessive small fruit (50 - 67 mm) may be produced, regardless of crop load. This effect has been associated with late and/or low volume applications, however the cause is not known. A preliminary study (1991; fruit diam., 11 mm; 15 mg·L$^{-1}$ equivalent at 234 - 2104 L·ha$^{-1}$) resulted in a high incidence (19 - 40 %) of small fruit. A later application (fruit diam., 20 mm, 701 L·ha$^{-1}$) had a lower incidence and fruit size approached that of hand thinned controls. In 1992, NAA (15 mg·L$^{-1}$, equiv.) was applied (fruit diam., 8 mm) at 250 - 2000 L·ha$^{-1}$. Time of application was assessed by applying NAA (15 mg·L$^{-1}$, high vol.) at 5 - 21 mm fruit diameter. At harvest, there was no significant amount of small fruit in any treatment. Fruit from NAA treatments were smaller than hand-thinned, but larger than non-thinned controls. Fruit size distribution showed no significant effect of spray volume or time of application. In a related study, a higher concentration (17 mg·L$^{-1}$) of NAA induced small fruit. The possible involvement of seasonal/environmental factors will be discussed.

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LOW-VOLUME APPLICATION OF ETHEPHON: SURFACTANT EFFECTS ON SPRAY DROPLET/DEPOSIT INTERACTION WITH LEAF SURFACES

M.J. Bukovac*[1], R.E. Whitmoyer[2], R.D. Brazee[3] and D.L. Reichard[3], (1) Dept. of Hort., Mich. State Univ., East Lansing, MI 48824, (2) Electron Microscopy Lab. and (3) USDA/ARS Appl. Tech. Res. Unit, Ohio Agr. Res. Dev. Ctr., Ohio State Univ., Wooster, OH 44691

Ethephon is applied to cherry trees as an aqueous spray to facilitate harvesting. Surfactants may be added to improve retention and coverage. We studied the effects of spray volume and surfactant on ethephon deposit formation on sweet cherry leaves using SEM and dispersive x-ray analysis. Cherry leaf surfaces have little epicuticular wax fine-structure hence are readily wetted; contact angle for upper and lower surfaces was 70-82° and 89-92°, respectively. Gum on the upper surface increased wetting dramatically. Droplets (0.24$\mu$l) with ethephon at concn (x = 400 mg l$^{-1}$, 5x, 10x, 20x, 40x) simulating spray volumes of x (full retention) to 1/40x resulted in deposits on the lower surface in the form of an annulus at high, and as discrete masses at low spray volumes. On the abaxial surface, the ethephon ppt as discrete masses over veins or anticlinal walls. Surfactant (0.1% Silwet L-77) increased deposit area with lesser effects as spray volume was decreased.

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ETHEPHON HARVEST EFFECTIVENESS ON OLIVE: SOLUTION pH, TIME OF APPLICATION, AND ADDITION OF BA OR NAA

James O. Denney* and George C. Martin, Department of Pomology, University of California, Davis, CA 95616-8683

We studied the effect on fruit and leaf abscission of application of ethephon (ETP) at 600 mg liter$^{-1}$ on excised fruit-bearing olive (*Olea europaea* L.) shoots held under controlled conditions of temperature and relative humidity analogous to field conditions during fall harvest. Fruit removal force (FRF) and percent leaf drop (%LD) were quantified. Raising solution pH did not improve harvest effectiveness. %LD was significantly higher than control at pH 5, but not at pH 3 or pH 7; FRF was not significantly affected by pH. %LD was not significantly higher than control in the time-of-application treatments (pH 3 only); FRF was significantly less than control when applied at 7AM or 12 noon, but not at 5PM or 10PM. Addition of NAA to the ETP solution raised FRF and lowered %LD; BA had the opposite effect. BA accelerated anthocyanin production on fruits. Regardless of treatment, FRF and %LD are highly but negatively correlated ($r^2$ = 0.62). Harvest effectiveness of ETP use on olive can be defined as a convergence of decreasing FRF and increasing %LD. Mean values for all ETP treatments were FRF = 3.0 N and %LD = 15%, acceptable values for effective olive harvest. Chemical names used: (2-chloroethyl)phosphonic acid (ethephon); naphthalene acetic acid (NAA); 6-benzylaminopurine (BA).

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EFFECT OF PINOLENE AND ABSCISIC ACID ON "BALADY" ORANGE TREES UNDER HEAT STRESS

Mohamed A.Bacha *,Moustafa El-Hamady and Hilal M. Abo-Asker,Plant Production Department , College of Agriculture, King Saud University , Saudi Arabia

Foliar sprays of pinolene (0,2 and 4%) and abscisic acid (ABA) (0,50 and 100ppm)were used to reduce heat stress effect on "Balady" orange trees under the Riyadh region,Saudi Arabia for two seasons. Pinolene treatments maintained higher leaf chlorophyll content than the control . Yield was slightly increased by pinolene treatments. Fruits had high values for most physical properties due to these treatments . TSS% and TSS/acidity ratio were increaced , acidity was decreased , while vitamin C was unaffected. Abscisic acid treatments reduced leaf chlorophyll content, compared to the control,but had no effect on yield. Such treatments increased fruit diameter(at 50 ppm) and fruit weight and juice volume (at 100 ppm). ABA showed no influence on most of the chemical properties of the fruits . In view of these results, it can be stated that pinolene was more influencial in reducing heat stress effect than ABA on "Balady"orange trees.

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EFFECTS OF GIBBERELLIN AND GIRDLING ON THE YIELD OF "NOVA" (CLEMANTINE x ORLANDO TANGELO) AND "NIVA" (VALENCIA x WILKING)

R. Goren, M. Huberman, Hebrew University of Jerusalem, Dept. of Horticulture, Rehovot, 76100, Israel.

$GA_3$ and/or girdling half of the main branches significantly increased both fruit set and yield, but caused the highest rate of fruitlet drop. Spraying $GA_3$ at mid-anthesis is the best treatment to improve fruit set and yield. Yield loss of up to 48% was due to rind-splitting-induced fruit abscission in August and mid-October. Morphological study of splitting revealed that this phenomenon occurred at the stylar end starting at the flavedo, progressing into the albedo and leaving the vascular bundles intact, although they separated later. Spraying Nova trees with different growth regulators in July, failed to reduce splitting. Reducing water supply by 35 or 50% from August onward, reduced rind splitting by up to 35% accompanied by a decrease in fruit size and yields. Internal quality was not affected when water supply was reduced by 35%. Reducing water supply by up to 50% decreased TSS/acid ratio and percent of juice. It is therefore questionable whether reduced water supply is an effective treatment for limiting rind splitting and premature fruit drop.

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# 130 ORAL SESSION 33 (Abstr. 267–273)
## Vegetable Crops: Stress Physiology

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RHIZOBIUM GROWTH AND SURVIVAL AS INFLUENCED BY TEMPERATURE

Raymond Baptiste*, Lurline Marsh, Dyremple Marsh, Department of Agriculture, Lincoln University, Jefferson City, MO 65102, and David Trinklein, Department of Horticulture, University of Missouri, Columbia, MO 65211.

The number of viable cells produced by Rhizobium on solid media gives an indication of the strains survivability when used as an inoculant. This study was conducted to determine the viability of different strains of Bradyrhizobium, and their ability to nodulate pigeonpea (Cajanus cajan) and cowpea (Vigna unguiculata) genotypes at two temperature regimes: 20/10°C and 30/20°C (day/night). Bradyrhizobium strains USDA 3278, 3362 and 3458 were cultured in yeast mannitol broth for 7 days from which a 10% dilution was made. From this dilution, 0.1 ml of a further $10^{-6}$ dilution was allowed to grow on yeast mannitol agar plates at the test temperatures. Strains cultured at 30/20°C had a higher number of viable cells than those cultured at 20/10°C for 4 days. While there was no difference between Rhizobium strains 3278 and 3362, strain 3458 had the highest number of cells per ml of 7-day old broth culture. Pigeonpea and cowpea plants inoculated at 20/10°C with the three Rhizobium strains and those inoculated with 3362 at 30/20°C had no nodules at 30 days after planting. At 30/20°C, pigeonpea and cowpea plants inoculated with strain 3458 produced a higher number of nodules than those inoculated with strain 3278. These results indicate that temperature influences the Rhizobium strains and their ability to nodulate pigeonpea and cowpea.

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INDUCTION OF CHILLING TOLERANCE DURING GERMINATION OF *CUCUMIS SATIVA* CV. POINSETT 76

Paul H. Jennings*, Horticulture Dept, Kansas State University, Manhattan, KS 66506 and Mikal E. Saltveit, Mann Lab, University of California, Davis, CA 95616

Cucumber seeds are resistant to chilling during imbibition but become sensitive on emergence of the radicle. Since temperature shock treatments have been shown to induce stress tolerance in other species, a project was initiated to determine the effects of various shock treatments on chilling tolerance during early stages of cucumber seed germination. Heat shock, cold shock and ethanol all induced tolerance of 24 hr germinated cucumber seeds chilled at 2.5°C for 96 hr. Both time and temperature (or concentration) of the shock treatment affected the level of induced tolerance. Heat shock at 40°C for 1 hr was most effective in inducing chilling tolerance. The effects of other shock treatments will also be discussed.

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**Response of cucumber and squash roots to chilling stress during early stages of seedling development.**

**Eleazar Reyes* and Paul H. Jennings.** Horticulture Department. Kansas State University. Manhattan, KS 66502

4 day old squash and 3 days old cucumber seedlings germinated at 26°C were exposed to 2, 6, 10 and 15°C for 1, 2, 4, 6, and 8 days. Root growth at 2°C and 10°C was inhibited 70% and 35%, respectively, compared to the 15°C control in both species. Chilling at 2°C for 4 days or longer resulted in irreversible injury as determined by the ability of the seedlings to resume growth when placed at 26°C. Seedlings of both species chilled at 10°C were able to resume growth when transferred to 26°C.Root membrane permeability as measured by leakage of electrolytes and organic compounds increased with time of chilling at 2, 6 and 10°C. A comparison of the specific ions leaking from chilled roots will be presented.

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MAIN VERSUS EXTERNAL ROOTS AND PHOSPHORUS EFFICIENCY IN COMMON BEAN: ARE ALL ROOTS CREATED EQUAL?

Sieglinde S. Snapp* and Jonathan Lynch, Department of Horticulture, The Pennsylvania State University, University Park, PA 16802

Separate evaluation of main and external roots was critical to understanding results from a study on phosphorus (P) efficiency in common bean. A subsection of the root system, including both main roots and external roots, was compartmentalized and subjected to low P conditions. The rest of the root system was maintained at either low or high P-nutritional status. P distribution at the mid-pod fill stage was determined for root components (main and external roots) and shoot components (leaves, stems, pods). A 50% inhibition in main root growth and moderate reductions in diameters of both root types were found in low P plants compared to high P plants. Marked reduction in main root growth, coupled with a limited reduction in external root growth and thinner roots, allowed low P plants to reduce biomass and P investment in compartments by 54 and 42%. Yet root exploration of the compartment, in terms of root length per soil volume, was similar for both low and high P plants. Further, P removal from compartments was similar for roots of low P plants and high P plants. Taken together, the data suggest efficiency of P acquisition in P-stressed common bean is enhanced by selective inhibition of main root growth and continued growth of external roots.

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GROWTH, SALT TOLERANCE AND MANNITOL ACCUMULATION IN CELERY

Susan C. Kann*, John D. Everard and Wayne H. Loescher, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325.

Mannitol, which in celery is a primary photosynthetic product, has been implicated along with other polyols in stress tolerance mechanisms as a possible osmotic regulator, compatible solute and free radical scavenger. We have characterized the growth of salt stressed celery, determined the extent of salt tolerance and showed a correlation between mannitol accumulation and salt tolerance.

Six, 8 and 12 week-old pot grown celery (*Apium graveolens* L.) plants of two cultivars were irrigated with up to 500 mM NaCl for 3.5 and 7 weeks. After 7 weeks, 12 week-old 'Giant Pascal' plants showed three major responses: 1) shoot wet wt increased as much as 30% at 25 mM NaCl but root wet wt decreased; 2) plants tolerated 500 mM NaCl, although at a severely reduced growth rate; 3) as salt concentrations increased mannitol concentrations increased in roots, leaves and petioles, while sucrose, the other photosynthetic product in celery, decreased. Although all ages of both cultivars tolerated the highest salt concentration used, the beneficial effect of 25 mM NaCl occurred only in 8 and 12 week-old 'Giant Pascal'. Root wet wt was reduced in all salt treated plants, irrespective of age or cultivar.

Regardless of age, cultivar and length of treatment, celery tolerated high salinity and sometimes even increased wet wt at low salinity. Mannitol accumulation and the ratio of mannitol to sucrose were both positively correlated with salt tolerance.

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VARIABLE CROP FACTORS FOR COMPUTING CABBAGE WATER USE

E.H. Simonne*, D.A. Smittle, W.L. Dickens, and J.R. Stansell, University of Georgia, Coastal Plain Experiment Station, Tifton GA 31793

'Rio Verde' cabbages (Brassica oleracea L.) were grown in drainage lysimeters on two soil types (Tifton loamy sand and Bonifay sand) in the spring and the fall of 1982, 1983, and 1985. Irrigation regimes consisted of applying water amounts equal to soil water deficit when the soil water tension at a 10-cm depth exceeded 25, 50, or 75 kPa throughout growth of the crops. Because the lysimeters were equipped with rainfall-activated shelters, water applications and evapotranspiration (ETc) were similar. Crop factors (CF) as functions of plant age (i) were computed for all combinations soil type-season-irrigation regime as the ratio between water applications and class A pan evaporation ($E_p$). No significant differences were observed among soil type or season, but irrigation regimes significantly affected ETc and CF(i). The highest ETc and leaf yields corresponded to the 25-kPa regime. $CF(i) = 0.025i - 0.00021i^2$, $0.023i - 0.00017i^2$, and $0.022i - 0.00017i^2$, for the 25-kPa, 50-kPa, and 75-kPa treatments, respectively ($R^2 = 0.97$). Therefore, daily ETc by cabbages can be computed with $E_p$ as $ETc = CF(i) \times E_p$ for scheduling irrigation.

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EFFECTS OF $CO_2$ ON LEAF STOMATAL CONDUCTANCE AND PRODUCTION OF LETTUCE AND RADISH

C.L. Mackowiak*, R.M. Wheeler, and N.C. Yorio, The Bionetics Corp. (clm, ncy) and NASA Biomedical Operations Office (rmw), Kennedy Space Center, FL 32899.

Lettuce (cv. Waldmann's Green) and radish (cv. Giant White Globe) plants were grown hydroponically with a 18-hr photoperiod and 300 $\mu$mol $m^{-2}$ $s^{-1}$ PPF. Treatments consisted of 400, 1000, 5000 and 10000 $\mu$mol $mol^{-1}$ carbon dioxide ($CO_2$). Leaf stomatal conductance was monitored with a steady-state porometer across one diurnal period at 21 days and all plants were harvested at 25 days. Conductance at 400 and 10000 was > 1000 $\mu$mol $mol^{-1}$ for lettuce and conductance at 5000 and 10000 was > 1000 and 400 $\mu$mol $mol^{-1}$ $CO_2$ for radish. Carbon dioxide treatments having the lowest leaf conductances also resulted in the highest yields, viz. 1,000 $\mu$mol $mol^{-1}$ $CO_2$ for radish and 5000 $\mu$mol $mol^{-1}$ $CO_2$ for lettuce. Dark-period conductance was higher at 5000 and 10000 $\mu$mol $mol^{-1}$ $CO_2$ compared to 400 and 1000 $\mu$mol $mol^{-1}$ $CO_2$. The higher dark-period conductances were 70% of the light-period rates for lettuce and 30% for radish. Water use efficiency (WUE) (g biomass kg $water^{-1}$) was lowest at 400 $\mu$mol $mol^{-1}$ $CO_2$ for both lettuce and radish and was highest at 1000 $\mu$mol $mol^{-1}$ $CO_2$ for lettuce and 5000 $\mu$mol $mol^{-1}$ $CO_2$ for radish. The results suggest that WUE was improved with moderate $CO_2$ enrichment but declined at very high concentrations, i.e. 10000 $\mu$mol $mol^{-1}$ for lettuce and radish.

# 131 ORAL SESSION 34 (Abstr. 274–281) Woody Ornamentals: Water Relations

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EFFECT OF TIMING OF DROUGHT STRESS ON GROWTH, DEVELOPMENT, AND LEAF WATER STATUS IN NORTHERN RED OAK (Quercus rubra L.) SEEDLINGS

Desmond R. Layne* and Patricia T. Tomlinson, USDA Forestry Sciences Laboratory, P.O. Box 898, Rhinelander, WI, 54501, U.S.A.

Northern red oak seeds planted in thoroughly watered peat:sand mix in 15 x 35 cm pots were grown through three flushes in environmentally controlled growth chambers (16h day, 27C, 600 $\mu$E $m^{-2}$ $s^{-1}$; 8h night, 21C). After planting, seedlings were: i. not watered (early); or watered 2X/week: ii. for 2 weeks (mid); iii. for 1 month (late); or iv. for the duration of the study (control). Plants from i-iii were not rewatered until severe water stress developed (as indicated by predawn leaf water potential, $\Psi$). Soil relative water content (RWC), determined by time domain reflectometry (TDR) was followed in conjunction with $\Psi$. RWC was calibrated to soil volumetric water content. As soil RWC decreased, $\Psi$ became more negative. Saturated soil had RWC of 28%. Moderate and severe water stress occurred at RWC of 15 and 12%, respectively. Timing of onset of water stress affected developmental rate. Shoot:root ratio was higher for early- than late-stressed or control plants. Whole plant biomass decreased compared to control by 85, 71, and 39%, when water stress was imposed early, mid, or late, respectively. Water stress imposed early during seedling establishment was more detrimental than stress imposed later. Early water stress greatly reduced leaf area and root system which significantly limited flush growth that occurred after rewatering.

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GROWTH AND WATER STRESS RESISTANCE OF *VIBURNUM PLICATUM* VAR. *TOMENTOSUM* IN PINE BARK-AMENDED SOIL.

C. B. Wood[1]*, T. J. Smalley[1], M. Rieger[1], and D. E. Radcliffe[2].
[1]Dept. of Horticulture, University of Georgia, Athens GA 30602.
[2]Dept. of Crop and Soil Science, University of Georgia, Athens GA 30602.

Container-grown *Viburnum plicatum* Thunb. var. *tomentosum* (Thunb.) Miq. were transplanted on May 1 into tilled plots, tilled plots amended with aged pine bark, and untilled unamended plots (control) within a greenhouse. Plants were irrigated weekly for three months prior to drought initiation. Root growth, shoot growth, leaf water status, and leaf expansion rates were measured to determine whether tilling or site amending enhanced drought stress resistance. Prior to drought initiation amended treatments had the greatest new root length. New root dry weight of amended plots was 57% greater than controls and 32% greater than tilled plots. Mean root system diameter was 111 cm, 87 cm, and 61 cm for amended, tilled, and control plots, respectively. The mean ratio of new root length (cm) to leaf area ($cm^2$) was 5.3:1 in amended plots, 2.2:1 in tilled plots, and 1.7:1 in controls. During the drought, midday relative leaf water content was lowest in controls, while the rate of leaf expansion was greatest in tilled plots. Changes in soil moisture were monitored using time domain reflectometry. Control plots had higher volumetric water content; however, moisture release curves suggest that tilled and amended plots contained more plant available water.

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EVALUATION OF REMEDIAL DRAINAGE, AERATION, AND SOIL-LOOSENING TECHNIQUES ON TWO LANDSCAPE TREES IN COMPACTED SOILS

Susan D. Day* and Nina L. Bassuk, Urban Horticulture Institute, Cornell University, 20 Plant Science Building, Ithaca, NY 14853

Landscape trees are frequently planted in heavily compacted soils, such as around newly constructed buildings or in urban areas. Under such conditions, trees frequently die, or decline prematurely. Techniques for ameliorating these conditions were studied: vertical drainage mat panels, gravel-filled sumps, soil trenching and peat-amended backfill. *Acer saccharum* Marsh. 'Seneca Chief,' a species sensitive to compaction stresses, and the less sensitive *Pyrus calleryana* Decne. 'Red Spire' were planted in a compacted clay loam. Shoot growth, root distribution and soil oxygen levels were measured over two growing seasons. Oxygen levels varied with treatment, but were not limiting to root growth. Shoot growth of pears was greatest for soil trenches. Except for the gravel-filled sumps, all other treatments also showed increased shoot growth compared to controls. Maple mortality was generally high and inversely correlated with field drainage.

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COMPARATIVE FLOOD TOLERANCE OF BIRCH ROOTSTOCKS

Thomas G. Ranney* and Richard E. Bir, Department of Horticultural Science, North Carolina State University, 2016 Fanning Bridge Rd., Fletcher NC 28732.

Survival, growth, and physiological responses were compared among flooded and non-flooded container-grown trees of 'Whitespire' Japanese birch (*Betula platyphylla* var. *japonica* 'Whitespire') grafted onto each of four rootstocks: paper birch (*B. papyrifera*), European birch (*B. pendula*), river birch (*B. nigra*) and Japanese birch. Separate studies were conducted in the fall of 1991 and spring of 1992. Under flooded conditions, of up to 44 days, plants on river birch rootstocks typically had one of the greatest rates of photosynthesis ($P_n$), stomatal conductance and, in certain cases, greater mean shoot growth rates and survival. Plants with European birch rootstock had similar survival rates to plants with river birch rootstocks, but they did not maintain as high $P_n$ under prolonged flooding, they had less root and shoot growth, and a greater number of abscised leaves under certain conditions. Paper and Japanese birch were the two taxa found to be most sensitive to flooding and shared the ranking of lowest survival rate following flooding. These results demonstrate that flood tolerance of 'Whitespire' birch can be considerably enhance when grafted onto river birch rootstock.

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DRIP IRRIGATION REQUIREMENTS FOR ESTABLISHING LANDSCAPE ORNAMENTALS

W.M. Weerts* and N.K. Lownds, Dept. of Agronomy & Horticulture, New Mexico State Univ., Las Cruces, NM 88003

Five landscape species, Baccharis pilularis, Fallugia paradoxa, Juniperus sabina 'Tamariscifolia', Leucophyllum frutescens, and Nerium oleander, grown in 3.8-l containers, were planted in a loam soil and mulched with pecan shells or rock. Plants were irrigated weekly at 25, 50, 75 and 100% of estimated potential evapotranspiration (PET) determined using mean canopy cover at the beginning of the experiment. Growth was measured every two weeks and aesthetic, flowering and fruiting evaluations were made weekly. Leucophyllum and Nerium grew rapidly at a constant rate throughout the season. Baccharis and Fallugia grew rapidly in May and June and slowly thereafter. Juniperus showed a continued, moderate growth rate. In addition, there were few differences in overall plant quality, flowering or fruiting across irrigation rates. The equation for determining the irrigation of ornamentals appears to be flawed. For Leucophyllum, at the 25% rate, it predicted 980 l/plant would be required during the season while only 22 l (2.4% of PET) was applied, producing excellent specimens.



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IMPROVED GROWTH OF PECAN AND ORNAMENTAL PEAR TREES IN CONTAINERS WITH WATER RESERVOIRS

Ken Tilt*, William Goff, John Olive and Ronald Shumack, Department of Horticulture, Rm 40 Extension Hall, Auburn University, AL 36849-5630

Growth of pecan (Carya illinoensis (Wangenh.) C. Koch 'Melrose') and pear (Pyrus calleryana Decne. 'Bradford') trees in the nursery was greater in containers designed to hold water in the lower portion. The water-holding reservoir was obtained either by placing 76 liter containers in a frame holding water to a depth of 5 cm, or by using containers with drainage holes 5 cm above the bottom. The continuous waterlogging at the bottom of the containers resulted in root pruning and root death in the lower portion of the containers, but roots grew well above the constantly-wetted zone. Fresh weight of tops, caliper, and plant height were all greater after two growing seasons in the containers with water reservoirs compared to similar containers with no water reservoirs.

280

DIURNAL VARIATIONS IN XYLEM FLUID CHEMISTRY OF LAGERSTROEMIA INDICA: AN ENDOGENOUS CIRCADIAN RHYTHM

Peter C. Andersen*, Brent V. Brodbeck and Russell F. Mizell, III. University of Florida NFREC-Monticello, Rt. 4 Box 4092, Monticello, FL 32344

A diurnal increase in the concentration of amino acids (and N/C ratio) in xylem fluid of Lagerstroemia indica occurred from ca. 1230 to 2030 HR. Diurnal trends were similar for irrigated or non irrigated plants. Since the concentration of total organic nitrogen, total amino acids and most individual amino acids (but not organic acids or sugars) were also proportional to xylem tension (Xt) two experiments were performed to discern whether variations in chemistry were due to diurnal changes in moisture stress. First, L. indica when exposed to variable levels of moisture stress during midday manifested an increase in organic acids and a reduction in the N/C ratio. Second, chemical profiles of xylem fluid were collected at noon and midnight and were compared for plants exposed to a natural photoperiod, constant darkness, or continuous light. After 1 day the midday increase in concentrations of amino acids persisted for all treatments; the variation was greatest (10-fold) for plants in constant darkness where Xt varied from 0.20 to 0.25 MPa. Only plants exposed to continuous light lost this tendency after 3 days. Thus, the circadian rhythm was endogenous, terminated in continuous light and not mediated by changes in moisture stress. Glutamine accounted for most of the diurnal variation in total amino acids, organic nitrogen or N/C ratio in xylem fluid.

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A HEAT BALANCE TECHNIQUE TO MEASURE THE MASS FLOW RATE OF WATER IN TREES

Patricia Lindsey*, Department of Environmental Horticulture, University of California, Davis, CA 95616
Sanjeev Chandra, Department of Mechanical Engineering, University of Toronto, Toronto, Ontario M5S 1A4 Canada

An improved gauge to directly measure the mass flow rate of water in a tree is described. Principal components of the gauge are: an electric band heater wrapped around a section of the stem; an temperature controller that switches the current to the heater on and off so as to maintain a constant temperature rise across the heated section; and a timer to record the total time that the heater has been switched on. An energy balance shows the mass flow rate of water to be proportional to the time of operation of the heater. Experimental measurements of the flow rate of water in a tree using the gauge agreed well with its recorded loss in weight over a 24 hour period (<3%) except on extremely hot days (>40°C, >50%). Subsequent adjustments to the design of the gauge have corrected these measurement errors related to ambient environmental conditions. These include lowering the thermal capacity of the insulation covering the gauge, and leaving a sufficient portion of the stem below the gauge uninsulated, to ensure that water flowing in the stem warms up enough to reach ambient temperature before it enters the gauge.

## 132 ORAL SESSION 35 (Abstr. 282–289)
## Small Fruits: Breeding and Genetics

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RASPBERRY BUSHY DWARF VIRUS IN RED RASPBERRY BREEDING PLOTS

Margaret M. Stahler*, Francis J. Lawrence, USDA-ARS, Horticulture Crops Research Lab, Corvallis, OR 97330; Robert R. Martin, Agriculture Canada, Research Station, Vancouver, British Columbia, Canada, V6t 1X2

Red raspberry (Rubus ideas L.) selection fields in Oregon were screened to determine the incidence and prevalence of Raspberry Bushy Dwarf Virus (RBDV), a pollen-borne virus, using enzyme-linked immunosorbent assay (ELISA). In total, 365 genotypes were tested from three different fields which contained both junebearing (JB) and primocane fruiting (PF) clones. Positive RBDV infected genotypes were 29% JB and 65% PF; 30% JB and 72% PF; 42% JB and 64% PR in the 1991, 1989-90, and 1985-89 established fields, respectively. Examination of all pedigrees of RBDV positive and negative JB selections were very similar containing both susceptible and resistant cultivar parents, especially 'Willamette,' considered immune. The PF selection pedigrees were very different from the JB pedigrees with the resistance status of the cultivar parents largely unknown. RBDV resistant genotypes from these selection plots could be useful parents in breeding programs.

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CHARACTERIZATION OF BLACKBERRY PYRENES

FUMIOMI TAKEDA*, Appalachian Fruit Research Station, ARS, USDA, 45 Wiltshire Rd., Kearneysville, WV 25430

Pyrene (the pit of a druplet) size is a factor contributing to blackberry fruit quality. Large pyrene size, based on weight, length, or volume, and "seediness" is undesirable in processed blackberry products. Several of the recently released eastern thornless and erect Arkansas blackberries can be alternative sources of quality fruits for processors. The purpose of this study was to compare pyrenes of blackberries from the Oregon (O), Arkansas (A), and eastern USDA (E) breeding programs. Pyrene size (length) ranged from 2.5 mm in 'Darrow' to 4.0 mm in 'Black Satin' and 'Merton Thornless'. Pyrenes of A blackberries generally were ellipsoidal and smaller than E blackberries which were "clam" shaped. Pyrenes of E blackberries such as 'Black Satin' and 'Chester' had a thick endocarp and were much thicker and wider than A and O blackberries. In contrast, several O blackberries including 'Marion' had flat pyrenes with a soft, thin endocarp. The results of this study indicate that the pyrene thickness trait is a major factor contributing to seediness.

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INHERITANCE OF FIELD REACTIONS TO GRAY MOLD, LEATHER ROT, AND ANTHRACNOSE OF STRAWBERRY

Brenda Olcott-Reid*, James N. Moore, and Ronald W. McNew, Dept. of Horticulture and Forestry, 316 Plant Science Bldg., University of Arkansas, Fayetteville, AR 72701

Inheritance of field reactions to three fruit rots of strawberry was studied in two complete diallele crosses between parents of varying rot susceptibility. Reaction to any of the three rots--gray mold, leather rot, and anthracnose--demonstrated a 0.61 to 0.67 correlation with reaction to total rots. Phenotypic and environmental correlations between incidences of the three rots were negligible, while a 0.43 genetic correlation was found for reactions to gray mold and leather rot. Overall broad-sense heritabilities for rot reactions of individual progenies of crosses were 0.16 for gray mold, 0.51 for anthracnose, 0.27 for leather rot, and 0.39 for total rots. Analysis of general and specific combining abilities in both dialleles indicates mostly additive gene action for reaction to gray mold, leather rot and total rots, with strong non-additive gene action for reaction to anthracnose.

'Earliglow' as a parent significantly reduced gray mold incidence in its progeny by 7.6 and 5.0 percentage points in the two dialleles, and significantly reduced total rot by 12.9 and 6.8 percentage points. 'Fairfax' as a parent significantly increased gray mold in its progeny by 3.2 percentage points, increased leather rot by 4.5 percentage points, and increased total rot by 8.7 percentage points.



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RANDOMLY AMPLIFIED POLYMORPHIC DNA (RAPDs) IN OCTOPLOID FRAGARIA
James F. Hancock* and Peter W. Callow, Department of Horticulture, Michigan State University, East Lansing, MI 48824

We have been screening Fragaria chiloensis, F. virginiana and elite breeding populations of F. x ananassa for polymorphisms using PCR and random 10 base sequences. Over 60% of the primers result in fragments that distinguish between the various genotypes. Many of them segregate as alleles at a single locus. This technology shows high promise as a means of distinguishing cultivars and developing a genetic map to aid in breeding.

286
MEIOTIC MECHANISMS FOR 2N GAMETE FORMATION IN WILD BLUEBERRY SPECIES
Debby M. Filler* and Nicholi Vorsa, Rutgers Blueberry and Cranberry Research Center, Chatsworth, NJ 08019.

In blueberries (*Vaccinium spp*), 2n pollen production has been identified in both diploid and tetraploid populations. High 2n pollen producers from diploid *V. elliotti*, diploid *V. darrowi*, and tetraploid *V. pallidum* were chosen for meiotic studies. Cytological examination revealed spindle abnormalities, including parallel spindles and tripolar spindles, as well as synaptic irregularities. These aberrations would result in gametes having the genetic equivalent of first division restitution near the centromere and in portions of the chromosome that are not recombinant. Such gametes would be expected to transmit a high level of heterozygosity to resulting progeny. Reciprocal diploid by tetraploid cultivar crosses were made to evaluate the viability of the 2n gametes in the diploids, and to assess the usefulness of the diploids as parents in a breeding program.

287
GENETIC LINKAGE MAP FOR BLUEBERRY (VACCINIUM spp.) USING RAPD MARKERS
Amnon Levi* and Lisa J. Rowland, USDA/ARS, Fruit Lab, Bldg. 004, Beltsville Agricultural Research Center-West, Beltsville, MD 20705

A genetic linkage map for blueberry has been constructed from over 60 RAPD (random amplified polymorphic DNA) markers that segregated 1:1 in a testcross population of about 40 plants. Prior to map construction, polymerase chain reaction conditions were optimized and RAPD marker reliability was confirmed. The mapping population was derived from a cross between diploid blueberry plants: F1 interspecific hybrid, 'US388' (V. darrowi, 'Fla4B' X V. elliottii, 'Knight'), and another V. darrowi, 'US799'. The map currently comprises 12 linkage groups corresponding to the basic blueberry chromosome number and covers a total genetic distance of over 800 cM, with a range of 2-30 cM between adjacent markers. Interestingly, a few pairs of marker loci behaved differently from both linked and unlinked loci, being found at a much higher frequency in the recombinant configuration than the parental configuration possibly suggesting selection for certain combinations of alleles.

288
QUALITATIVE VARIATION IN FLORIDA BLUEBERRIES
Paul M. Lyrene, Horticultural Sciences Department, University of Florida, 1137 Fifield Hall, Gainesville, FL 32611

Most genetic variation in blueberries is quantitative. However, after a decade of exploration among Florida's native blueberry populations and more than 100,000 seedlings grown in nursery plots, several qualitative variants have been found. An allele for anthocyanin-free foliage in Vaccinium elliottii is recessive to wildtype. A second recessive allele at a different locus in the same species depletes anthocyanin in the fruit but not the foliage. A recessive allele in V. ashei produces white, pink, or purple berries when homozygous, the color depending on the clone that is made homozygous for the allele. A dominant allele in V. darrowi produces pink fruit and is nonallelic with the fruit anthocyanin deficiency allele in V. elliottii. Two V. elliottii clones with a weeping to prostrate growth habit have been found in west Florida. This phenotype is maintained by clonal propagation, but its inheritance has not been determined. A V. ashei plant with compact growth habit transmits this phenotype to a small percentage of its F-1 progeny when crossed with most V. ashei cultivars.

289
MOLECULAR GENETIC MAPPING AND GENOME SIZE OF *VITIS*.
Muhammad A. Lodhi*, Bruce I. Reisch and Norman F. Weeden, Department of Horticultural Sciences, New York State Agricultural Experiment Station, Cornell University, Geneva, NY 14456.

A project to develop a linkage map of the *Vitis* genome is underway using an interspecific hybrid grape population from 'Cayuga White' x 'Aurore'. The linkage map is based on 15 isozyme, 13 RFLP and more than 350 RAPD markers. This information is being combined with segregation data for viticulturally important traits including disease resistance to identify QTLs and mark simply inherited traits. Molecular markers, when linked with morphological traits, will find great application in map-based cloning and marker-assisted selection in grape breeding. We have also analyzed genome size of three genera of *Vitacae* (*Ampelopsis*, *Parthenocissus* and *Vitis* ) and 15 *Vitis* species as well as 15 diploid cultivars using flow cytometry. DNA content varied from 0.84 to 1.40 pg/2C. The relative small genome size indicates that *Vitis* is a good candidate for molecular genome analysis. All this information will help us understand *Vitis* genome organization and reliability of identifying a gene linked to a marker in different populations.

## 133 ORAL SESSION 36 (Abstr. 290–295)
## Cross-commodity: Modeling

290
SHOOT-TIP ENERGY BALANCE IN THE GREENHOUSE ENVIRONMENT
James E. Faust* and Royal D. Heins, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

The shoot-tip energy balance of Vinca (*Catheranthus roseus* L.) plugs in the greenhouse environment was quantified. The components of the energy-balance model were measured for four stages of plug development. A pyranometer and a total-hemispherical radiometer were used to measure the radiation component of the energy balance. A hot-wire anemometer was used to measure air velocity and fine-wire thermocouples measured air and plant temperatures. Evapotranspiration was measured with thin-beam load cells and a dewpoint hygrometer was used to determine the vapor-pressure deficits. The vinca plugs were grown in a greenhouse with the air temperature maintained at 20C±1. Shoot-tip temperatures at night were usually 2 to 4C cooler than air temperatures due to radiant energy losses. Shoot-tip temperatures remained below air temperatures during the photoperiod whenever solar radiation was less than 150 W $m^{-2}$. As the solar radiation increased above 150 W $m^{-2}$, shoot-tip temperature increased with respect to air temperature. A model was then developed to predict shoot-tip temperature based on measured greenhouse conditions. Experimental results were validated in several commercial greenhouses.

291
MODELLING WATER USE OF GRAPEVINE
Larry E. Williams, Department of Viticulture and Enology, University of California - Davis, Kearney Ag Center, 9240 S. Riverbend Ave., Parlier, CA 93648

An ongoing study measuring grapevine (*Vitis vinifera* L., cv. Thompson Seedless) water use with a weighing lysimeter is being used to develop a model to simulate vine water use on both a diurnal and seasonal basis. A method to calculate the aerodynamic resistance ($r_a$) of the vines was first determined. Subsequently, a model to predict canopy resistance ($r_c$) based solely upon intercepted photon flux density (PFD) was developed. The modeled values of $r_a$ and $r_c$ were substituted into a resistance-energy balance equation to predict vine ET. The modeled parameters were validated against diurnal measurements of ET from the lysimeter. The greatest difference between modeled and measured $r_c$ occurred prior to 1000 h and subsequent to 1500 h each day. The model overestimated vine ET by 14 and 23% on 16 and 24 June, 1992, respectively. Ambient temperature and vapor pressure deficit were greater on 24 June than on 16 June. Refinements in calculating PFD interception by the vine's canopy early and late in the day and incorporating the effects of other environmental factors on grape stomatal conductance should improve the predictive capabilities of the model.



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PREDICTION AND CONTROL OF STEM ELONGATION IN POINSETTIA

Paul R. Fisher* and Royal D. Heins, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

A stem elongation model is being developed for pinched poinsettia crops as part of a decision support computer program, the '*Greenhouse CARE System*'. Internode elongation is modelled as a function of DIF (day minus night temperature), plant density, and growth retardant applications. Average daily temperature and flower initiation date are used to determine internode number. Dose response curves are being developed to describe internode response to growth retardant applications, as affected by chemical type, concentration, time of application, and application method. The impact of plant density on growth and development is being modelled, and a spectroradiometer is being used to measure the effect of neighbouring plants on the light quality and quantity surrounding an individual plant. The model takes into account cultivar differences in their response to growth retardants and plant density. Output from the model is used to predict the short-term change in plant height under commercial greenhouse conditions. An interactive graphical interface to the model allows the comparison of alternative height control strategies.

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USE OF A MODIFIED RICHARDS FUNCTION TO SIMULATE SHOOT ELONGATION IN CHRYSANTHEMUM.

J. Heinrich Lieth* and Rolf U. Larsen, Environmental Horticulture, University of California, Davis, CA 95616, USA and Dept. of Horticulture, Swedish University of Agricultural Sciences, S-23053 Alnarp, Sweden.

The Richards function has been shown to be a useful, flexible model for growth of plants and plant parts which follows a sigmoid pattern. Such a pattern is seen frequently in horticultural crops. The objective of this project was to explore the feasibility of using this model in conjunction with potted plant cropping systems to simulate shoot elongation. In this study, the experimental system consisted of potted chrysanthemum (Dendranthema ×grandiflora) grown under various light and temperature regimes and subjected to growth regulator (daminozide) treatments. Shoot length was measured several times weekly while electronically logging environmental data continually. One or more daminozide applications were made in some treatments. The results indicate that very precise shoot length prediction is possible using this model. The differential equation on which this model is based was modified for use in a simulation model. The fits were very good, particularly for the growth regulator effect. Once validated for accurate representation of temperature and light, this model will have applicability as a production management tool for potted chrysanthemum.

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EFFECT OF SEASON ON GROWTH OF LETTUCE IN A COLD FRAME

Martin P.N. Gent*, Dept of Forestry and Horticulture, The Connecticut Agricultural Experiment Sta., New Haven CT 06504

In a cold frame, the growth rate of lettuce varies with season. At regular intervals in fall, winter and spring, two-week-old lettuce seedlings were transferred to a cold frame. The leaf area and dry weight were measured at the time of transfer, after 5 to 10 days, and after 10 to 20 days in the cold frame. The relative growth rate, RGR, leaf area ratio, LAR, and net assimilation rate, NAR, were calculated and regressed against averages for temperature and light for each growth interval. RGR varied from 0.07 day-1 in midwinter to about 0.30 day-1 in late spring. Leaf area RGR depended on temperature and dry matter RGR depended on light. However light and temperature were correlated, R2 = 0.62. Temperature extremes decreased RGR if the maximum exceeded 25C or if minimum fell below 0C. LAR increased with temperature, primarily, but also decreased with light. NAR depended on light to the second order, with a half maximum response at 4 Mj.m-2.d-1 total irradiance, and increased linearly with temperature. The dependence on solar insolation for warmth decreased growth rates in midwinter to about half that expected in a heated greenhouse.

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**OPTIMAL SPACIAL ORIENTATION OF TREE CROPS BASED ON MAXIMIZING SUNLIGHT INTERCEPTION DURING CRITICAL GROWTH AND DEVELOPMENTAL WINDOWS**

Bruce W. Wood, Jeffrey Burcaw*, Michael W. Poole, and Mark T. Burnette, USDA/ARS Southeastern Fruit and Tree Nut Research Laboratory, Byron, GA 31008

Tree crops are often planted at particular geometrical and spacing patterns with little or no quantitatively based data on how the arrangements influence sunlight interception and productivity.

We have developed a mathematical model describing intertree shading derived from computer simulations of tree growth and light extinction through the canopy. Variables include tree shape, intertree spacings, orchard geometry, geographical coordinates, season, and time of day. This model predicts the extent of intertree shading during the daily interval of maximum photosynthesis for any combination of these conditions and indicates that optimal orchard design is unique for each latitude and tree crop. It can be used by the orchardist to establish orchards in which trees receive maximum levels of sunlight within specific windows of time; for example, during the period of fruit development or during the accumulation of dormant season assimilate reserves.

## 134 ORAL SESSION 37 (Abstr. 296–301) Cross-commodity: Education

296

PROVIDING ACCESS TO UNIVERSITY EDUCATION IN HORTICULTURE: PARTNERSHIPS THROUGH TECHNOLOGY

Judith D. Caldwell*, Department of Horticulture, Clemson University, Clemson, S.C. 29634-0375.

Clemson University and Horry-Georgetown Technical College are using communications technology and non-traditional strategies to offer university horticulture education opportunities to a much larger and more diverse student clientele than is currently served by the traditional campus. This pilot project focuses on delivery of a complete Clemson horticulture/turfgrass science baccalaureate degree program through the technical campus. This partnership was selected for the pilot project, in part, because of the strong commitment to turfgrass related educational programs at each school. Faculties and administrators worked together to remove "campus-bound education" barriers and develop alternate degree pathways. A critical component of this pathway is the offering of select courses through Clemson TELECAMPUS, which delivers live, interactive instruction throughout South Carolina via the South Carolina Educational Television system. The Clemson University Forestry and Agriculture Network (CUFAN) will be used to further enhance interactive opportunities between students and instructors, and to access university support facilities. Additional campus services and resources will be focused to provide an innovative and enriched distance learning opportunity.

297

DEBATES--A TOOL TO HELP STUDENTS THINK ABOUT HORTICULTURAL ISSUES

Janice Coons,* Botany Department, Eastern Illinois University, Charleston, IL 61920

Routine methods of teaching often do not challenge a student's ability to think creatively and independently. In many horticulture classes the emphasis is on learning of facts, principles, and techniques, rather than the consideration of controversial issues such as chemical usage. I have used student debates as a tool to discuss various horticultural issues which are controversial. Possible debate topics, methods for the presentation of the debates, and ways to evaluate the debates will be presented. The use of debates in horticulture classes will be considered from the perspective of both students and the instructor. Both strengths and weaknesses of student debates as a learning experience in horticulture classrooms will be presented.



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USING PROBLEM-SOLVING OPPORTUNITIES TO IMPROVE HORTICULTURAL EDUCATION
C. B. McKenney,* Department of Agronomy, Horticulture, and Entomology, Texas Tech University, Lubbock, Texas 79409-2122

Historically horticulture students have received excellent scientific and technical training through their degree programs but they must rely on internships to develop the implementation skills and "hands-on" experiences necessary to be successful. With the use of creative term projects, many problem solving opportunities can be integrated into the curriculum enhancing synthesis level decision making. At Texas Tech this is accomplished by identifying a campus interiorscape requiring renovation. Interior Plants students are then asked to develop a design solution which utilizes existing plant materials. The designs are evaluated and the best one is selected. The class then installs the design providing them the chance to select estimate and source materials within a limited budget, work with clients, comply with state operating procedures, and coordinate with various campus work units. The project provides the students with the transition experience from lecture to implementation while instilling self-confidence.

300
IMPORTANCE OF HORTICULTURE INSTRUCTION IN SECONDARY AGRICULTURAL EDUCATION PROGRAMS IN NEBRASKA
Craig Frederick, Jay B. Fitzgerald*, Allen G. Blezek and Roy D. Dillon, Departments of Agricultural Education and Horticulture, University of Nebraska, Lincoln, Nebraska 68583

A survey was used to identify specific elements of the horticulture curriculum included in Nebraska Secondary Agricultural Education programs as perceived by nurserymen, garden center operators, and Nebraska secondary agricultural education teachers. A comparison of Nebraska nurserymen's and Nebraska secondary agricultural education teachers' rating of horticulture curriculum content was determined and specific skill areas were identified which are important for employment in the horticulture field.

The statistical comparisons of Nebraska Association of Nurserymen members' and Nebraska secondary agricultural education teachers' rating of skill areas and curriculum content for employment in the horticulture field in Nebraska will be discussed.

301
**INTERIOR PLANTS IN A CLASSROOM IMPROVE AIR QUALITY AND THE LEARNING ENVIRONMENT**
Georgia K. Goodwin* and Virginia I. Lohr, Department of Horticulture and Landscape Architecture, Washington State University, Pullman, WA 99164-6414

Plants were added to a college computer lab to determine their effect on air quality and their influence on human psychological and physiological responses. Sixteen plants of varying size and color were added to a stark computer room that measured approximately 8 m x 13 m. Temperature, humidity, carbon dioxide, particulate matter, and human response were monitored in the presence and absence of plants.

The addition of plants enhanced the learning environment physically and psychologically. Relative humidity was slightly, but significantly, higher when plants were in the room than when they were absent. Particulate matter accumulation was found to be less than half as much in the presence of plants compared to accumulation in the absence of plants.

## 135 ORAL SESSION 38 (Abstr. 302–309) Vegetable Crops: Breeding and Genetics

302
A NEW SOURCE OF RESISTANCE TO ANTHRACNOSE (RACE 2) IN WATERMELON
J.D. Norton*, G.E. Boyhan, B.R. Abrahams and H.W. Huang, Department of Horticulture, Alabama Agricultural Experiment Station, Auburn University, Alabama 36849

In a screening test of 76 PIs, commercial Chinese watermelons, and 'Crimson Sweet', PI512385 had the highest disease resistance with a mean rating of 4.5 on a 1-9 scale with 1 = resistant and 9 = susceptible. A second test with PI512385 included material with previously reported resistance (PIs 270550, 326515, 271775, 271779, 203551, 299379 and 189225) and 'Crimson Sweet', a susceptible check showed PI512385 had significantly more resistance than 'Crimson Sweet' but was not significantly more resistant than the PIs. PI512385 had a mean rating of 2.2 in the second test.

303
EVALUATION OF RESISTANCE TO THE FLORIDA AND EGYPTIAN STRAINS OF ZUCCHINI YELLOW MOSAIC VIRUS IN WATERMELON AND RELATED GERMPLASM
G.E. Boyhan*, J.D. Norton, R.T. Gudauskas, and B.R. Abrahams, Department of Horticulture and Plant Pathology, Auburn University and Alabama Agricultural Experiment Station, Auburn University, AL 36849-5408

Six lines of watermelon or related germplasm were evaluated for resistance to the Egyptian strain of zucchini yellow mosaic virus (ZYMV-E). 'Egun' had the highest level of resistance of the lines tested based on enzyme-linked immunosorbent assays and visual ratings. PIs 386025, 386026, and 494528 appear to have intermediate resistance.

PIs 386025 and 386026, both resistant to the Florida strain of ZYMV, were analyzed in crosses with 'AU-Producer'. No Mendelian ratios were evident, therefore generation mean analysis was used to evaluate this material.

304
CYTOLOGICAL EXPRESSION OF *ms* MUTANT IN WATERMELON
X. P. Zhang*, B. B. Rhodes, Dept. of Hort., and H. Skorupska, Dept. of Agronomy and Soils, Clemson University, Clemson, SC 29634

Cytological studies on a male-sterile, female-fertile mutant *ms* in watermelon were done to determine differences in gene expression and stage of microsporangium development between male-sterile and male-fertile genotypes. Anthers of male-sterile (*msms*) and normal (*Ms*__) plants of a line G17AB were compared using a single-staining procedure for sporopollenin, a double-staining procedure for nucleic acid and polysaccharides and a triple-staining procedure for DNA, protein and polysaccharides with bright field and fluorescent microscopy. No distinguishable features were observed between sterile and fertile plants at the microsporogenous stage. By microsporocyte stage, tapetum surrounding the sporocytes was differentiated and enlarged in normal plant anthers. There was no tapetum differentiation in *ms* mutant, and sporangium wall consisted of 5-7 layers of small cells. Ontogeny of microsporocytes of *msms* stopped at telophase II. The tetrad stage was not observed in the male-sterile plant. As maturation of *msms* anthers progressed, sporangium locules collapsed, and the telophase II meiocytes degenerated. Degenerated meiocytes in the collapsed locules gave low density primuline-induced fluorescence. All of these features suggest that the *ms* gene is expressed at a very early stage of microsporangium development (before meiosis) and results in failure of the tapetum to differentiate. Absence of tapetum results in abortion of meiocytes. Developmental bases for this male-sterility may be attributed to mutation in sporophytic anther tissue.

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CONSTRUCTION AND APPLICATION OF A GENETIC LINKAGE MAP IN CUCUMBER

Wayne C. Kennard* and Michael J. Havey, Department of Horticulture, 1575 Linden Drive, University of Wisconsin, Madison, Wisconsin 53706

Genetic linkage maps have been proposed as tools for crop improvement. We constructed a genetic linkage map of cucumber including RFLP, RAPD, isozyme, and disease resistance markers. The map was used to determine the number, magnitude of effects, and action of genes conditioning quantitatively inherited fruit-quality traits, including length, diameter, seed cavity size, and color. Traits were evaluated in a replicated field trial over 2 years. A mating design was employed to confirm putative trait loci across generations and estimate overall genetic variances for the quality traits. For some traits, gene number estimates were similar to previously published reports employing biometrical methods.

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ASSESSMENT OF RAPD'S IN CUCUMBER (*Cucumis sativus* L.)

J. Staub and K. Poetter
USDA-ARS and University of Wisconsin, Horticulture Department, 1575 Linden Dr., Madison, WI 53706.

Very little information exists regarding linkages in cucumber. There are 5,460 pairwise combinations which could be tested among the 105 described genes. Linkage information is available for only 3.2% of these possible pairwise comparisons. Our research unit is involved with mapping isozymes, RFLP's and RAPD's.

We have used F2 and BC progeny to construct RAPD maps and have found that although polymorphisms are present in cucumber they are not remarkably more frequent than molecular polymorphisms found using RFLP's. For example, we screened 1051 primers and detected roughly 140 possible polymorphisms between two inbred lines. Assessment of F2 progeny segregations resulted in the identification of 70 usable polymorhphisms. Approximately 40 of those markers segregated in an expected 3:1 ratio. An additional 11 markers segregated in a 1:1 ratio. Using a threshold of 32 cM, eight linkage groups were identified containing a total of 37 markers. In another F2 population within and between laboratory results were compared to determine error rates (1 to 5%). Data from a third F2 population suggest that there may be loose phenotypic correlations between RAPD primers and the determinate character ($r^2$ = 0.54) and sex expression ($r^2$ = 0.68). These associations are being further characterized using BC1 and F2 progeny.

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LINKAGE BETWEEN ISOZYME MARKERS AND DISEASE-RESISTANCE GENES IN CUCUMBER (*Cucumis sativus* L.)

V. Meglic*, A. Dijkhuizen, W. Kennard, M. Havey and J. Staub
USDA-ARS and University of Wisconsin, Horticulture Department, 1575 Linden Dr., Madison, WI 53706.

Two hundred F2 cucumber (*Cucumis sativus* L.) families from crosses between GY14 (U.S. processing type) and PI 432860 (long greenhouse type) and GY14 and PI 183967 (*C. sativus var. hardwickii*) were evaluated for allozyme polymorphisms. Polymorphisms were detected at Fdp2, Mdh3, Mpi1, Pep-gl, Pgm1, Idh2, Pep-pap and Per. Subsequently they were scored for resistance to anthracnose (*Colletotrichum lagenarium*), scab (*Cladosporium cucumerinum*) and angular leaf spot (*Pseudomonas lachrimans*).

Estimates of the recombination frequencies confirmed previously established linkage groups among allozyme markers (Knerr and Staub, 1992) and revealed new associations between allozyme loci and disease resistance genes. Scab appears to be tightly linked to and flanked by Fdp2 and Mdh3.

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INDO-US *CUCUMIS* GERMPLASM EXPEDITION

James D. McCreight,* Agricultural Research Service, U.S. Department of Agriculture, 1636 East Alisal Street, Salinas, CA 93905 (USA), Jack E. Staub,* Agricultural Research Service, U.S. Department of Agriculture, Department of Horticulture, University of Wisconsin, Madison, WI 53706 (USA), and N. M. Koppar and U. Ch. Srivastava, National Board for Plant Genetic Resources, Pusa, New Delhi-110012 (India)

Fruits and seeds of cucumber (*Cucumis sativus* L.), melon (*Cucumis melo* L.), 11 other cucurbit species and five non-cucurbit species were collected in the states of Rajasthan, Madhya Pradesh, and Uttar Pradesh in October and November, 1992. Seeds were collected from cultivated and non-cultivated areas, vegetable markets (subji mundi), and from seed dealers. Though many samples were collected as fruit, we were not always able to observe the plants or the growing areas. The origin, description, and use of the collections were noted at the collection site whenever possible. Cucumber landraces were scarce whereas melon landraces were abundant. Of the 681 collections, there were approximately 186 cucumbers and 447 melons. Exact numbers will be known after discrepancies in the records have been resolved. These seeds will be available after they have been increased and documented in the U.S. Germplasm Resources Information Network (GRIN) database. To that end, 1993 plans call for increase, and morphological and biochemical evaluations of a significant portion of the cucumber and melon collections in the U.S., and a substantial parallel increase and morphological evaluation of the collections in India.

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DEVELOPMENT OF A NUMBER OF PARTHENOCARPIC CUCUMBER HYBRIDS IN IRAQ

Faisal A. Al-Mukhtar, Department of Horticulture, College of Agriculture, University of Baghdad, Iraq

The objective was to develop F1 parthenocarpic cucumber hybrids adapted to greenhouse and plastic house culture. Thirteen gynoecious inbred lines were developed through successive selfing for six generations, followed by strict selection and screening in each cycle. General and specific combining ability tests were conducted using all possible reciprocal crosses. Four F1 hybrids were selected and compared in variety trials in different seasons with the commercially grown 'Maram' hybrid. The local hybrid IPA-C2005 ranked the best for various yield components. No significant difference was observed between the yield of IPA-C2005 and 'Maram' hybrid. The marketable yield estimates were 2.182 and 2.150 MT/180M$^2$ for both hybrids, respectively.

## 140 WORKSHOP 9 (Abstr. 310–313) Establishment of Asexually Propagated Fruit and Vegetable Crops: Traditional and Biotechnological Approaches

310

TRADITIONAL SWEETPOTATO AND POTATO STAND ESTABLISHMENT CONSIDERATIONS

Melvin R. Henninger, Rutgers University, P.O. Box 231, Blake Hall, New Brunswick, New Jersey 08903-0231 U.S.A.

Less attention is paid to the stand establishment of transplanted or seedpiece propagated crops because of the large amount of plant material used compared to a small vegetable seed; however, many crop failures have resulted from this lack of concern by growers and researchers.

With commercial sweetpotato production, the whole root is planted in a bed to produce the transplant. The pre-conditioning of the roots and the care of the bed are both very important to the production of good transplants. Field establishment is equally as critical.

With commercial white potato production in the developed world, seedpiece propagation is used to establish the crop. Seedpiece size and pre-conditioning, as well as soil conditions, at and after planting are the most important considerations.

Research studies on the size and pre-conditioning of the seedpiece and the plant population of these species as they relate to size and quality of the saleable product will be discussed. Grower observations of tillage practices which have produced the good stands will also be included.

311

SEXUALLY PROPAGATING POTATOES

Noel Pallais*, International Potato Center, Apartado 5969, Lima, Peru.

The importance of sowing vigorous seed is particularly well recognized by commercial growers of small-seeded sexually propagated crops. The possibility of producing clean potato seed tubers with true potato seed (TPS) has existed in many developing countries since the seventies. In China, about 15,000 ha of potatoes are grown with seed tubers originally derived from TPS. The possibility to establish a fast field-stand and to produce a commercial crop of potatoes within 90 days after transplanting TPS seedlings has only been recently realized. This paper outlines the methodology used and the results obtained during 10 years of study focusing on the most critical factors involved in the production and preservation of high-quality TPS. Seed dormancy accounts for the most important difference between the undomesticated TPS and other related crops such as the tomato.

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MICROPROPAGATION AND SOMATIC EMBRYOGENESIS OF SWEETPOTATO, EFFECTS ON PLANT GROWTH AND YIELD

Jonathan R. Schultheis*, Wanda W. Collins and Daniel J. Cantliffe
Dept. of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609 and Horticultural Sciences Dept., University of Florida, Gainesville, FL 32611

Commercial sweetpotato fields are established with asexually derived propagules as either cut or pulled plants. Micropropagation and somatic embryogenesis were/are being investigated to improve seed production. Micropropagation of sweetpotato is utilized in California as part of its seed production program. Several studies have been conducted or are ongoing in North Carolina to evaluate the utility of micropropagation as part of its certification program. In 1992, yield was increased in 'Beauregard' with micropropagated plants compared with plants that were derived from the North Carolina Certified Seed Program. However, there were no yield increases in four years of comparisons when 'Jewel' and 'White Delight' were micropropagated. A trend towards early bulking has consistently been observed in micropropagated 'Jewel', 'White Delight' and Beauregard. Early plant growth and yields of plants ('White Star') obtained from somatic embryos, micropropagation or vine cuttings were compared. Plants derived from somatic embryos grew slower and yielded less root weight than cut plants; however, more storage roots were obtained from plants obtained from somatic embryos indicating high yield potential if root bulking is achieved.

313

USE OF SYNTHETIC SEED TECHNOLOGY AND OTHER NON-CONVENTIONAL PROPAGATION METHODS

D. J. Gray* and M. E. Compton, Central Florida Research and Education Center, University of Florida-IFAS, 5336 University Ave., Leesburg FL 34748

For certain crops, the high cost of stand establishment and/or maintenance has stimulated the search for alternative propagation systems. This presentation discusses the possible applications of these systems to high value crops. Germplasm conservation of vegetatively propagated or recalcitrant seeded crops is difficult due to the high cost of stand maintenance. Utilization of synthetic seed technology (i.e., somatic embryos) would allow clonal germplasm to be economically conserved in seed repositories. Many ornamental crops with high per-plant values are now laboriously micropropagated via organ culture. Substitution of synthetic seed technology for propagation of such crops would decrease production costs by reducing labor. Similarly, field establishment of seedless watermelon can cost $0.40 or more per plant, whereas synthetic seed cost has been calculated (for alfalfa) at $0.04 per plant; approximately 10% less than that of conventional seed. In seedless watermelon variety development, simple micropropagation can be used to reduce the time required for commercial seed increase of new tetraploid parental lines from ten years to less than one year.

## 141 WORKSHOP 10 (Abstr. 314–315)
## New Innovations in Lamps for Plant Lighting

314

MICROWAVE-POWERED LAMPS: A NEW SOURCE OF HIGH INTENSITY LIGHTING

Donald T. Krizek*, Steven J. Britz, and Roman M. Mirecki, Climate Stress Laboratory, NRI, ARS, U. S. Department of Agriculture, Beltsville, MD 20705-2350

Although microwave-powered systems have been used for nearly two decades as UV sources for annealing and other industrial processes, recent discoveries indicate that these systems may also have application in providing a source of high intensity lighting. The spectral characteristics of newly developed microwave-powered lamps will be described in comparison to sunlight and a mixture of high pressure sodium and metal halide lamps. The responses of plants grown under these sources will be compared.

315

EVALUATION OF LUMINARES FOR HID LIGHTING

Robert W. Langhans, Cornell University, Ithaca, NY 14853

Luminares are the vehicle used to reflect and direct the light energy from the lamps to the desired area. There are many companies manufacturing luminares and many different designs. The efficiency of the luminare can vary greatly from one design to another. We attempted to measure the efficiency of a selected group of luminares. The results were confusing as we will show and further investigations into this problem uncovered the major reasons for the discrepancies and difficulties in coming to a simple recommendation.

## 144 WORKSHOP 13 (Abstr. 316–319)
## Wild Nuts of Eastern North America

316

**THE GENUS CARYA IN NORTH AMERICA.**

**L. J. Grauke, USDA, ARS Pecan Breeding and Genetics, Somerville, TX 77879**

**The genus Carya is represented in North America by two Sections, with 14 species. Section Apocarya includes 4 U.S. and 1 Mexican species, all of which are diploid (n=16). The only commercially important Apocarya species is pecan, Carya illinoinensis (Wangenh.) K. Koch. Utilization and possible dissemination of pecan by man is evident in the archeological record to 6000 B.C. Patterns of genetic diversity in pecan in relation to geographic origin will be discussed for both native and cultivated trees. Other species of section Apocarya will be introduced and their potential role as rootstocks or for cultivar development through interspecific hybridization will be discussed. Section Carya includes 9 species, some of which are diploid (n=16) and some tetraploid (n=32). Horticultural selection has been greatest in the diploid species of the section [C. ovata (Mill.) K. Koch and C. laciniosa (F. Michx.) Nutt.]. Native species distributions and prominent cultivars will be discussed, along with problems associated with commercial culture of hickories.**

317

EASTERN BLACK WALNUT - POTENTIAL FOR COMMERCIAL NUT-PRODUCING CULTIVARS

William Reid*, Kansas State University, Pecan Experiment Field, P.O. Box 247, Chetopa, KS 67336.

Over 10,000 metric tons of eastern black walnut, Juglans nigra L., are harvested annually in the U.S. This production is based entirely on hand harvested nuts from seedling trees growing in native stands throughout the midwest and northeast. Significant improvement in nut quality and yield could be made for black walnut through the selection and propagation of superior clones. Cultivars have been identified that exhibit one or more of the important genetic traits needed for crop improvement. These traits include: lateral bud fruitfulness, late leafing, resistance to Gnomonia leptostyla (Fr.) Ces. & de Not., precocity, thin shell thickness, high percent kernel, ease of shelling, and light colored kernels. Cultivars that bear nuts on lateral branches and produce nuts with more that 30% kernel are currently available. If planted in an orchard situation, these cultivars could have an immediate impact on the black walnut industry. Commercial black walnut orchards based on thin shelled cultivars have not been developed due to the lack of cultivar performance data and undemonstrated crop profitability. Large trial plantings that become financial successful will be necessary to stimulate a black walnut orchard industry. The incorporation of additional positive traits into walnut cultivars will only be made after an established walnut industry demands further crop improvement.



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MANAGEMENT TOOLS FOR TREE NUT CROPS: WHAT ABOUT THE SOUTHERN OSCILLATION?

Bruce W. Wood, USDA-ARS, Southeastern Fruit and Tree-nut Research Laboratory, Byron, Georgia 31008

Worldwide weather is closely associated with a cyclic oscillation in atmospheric pressure in the equatorial Pacific Ocean. This Southern Oscillation event affects regional weather via atmospheric teleconnections in both the Northern and Southern Hemispheres. When these episodes exceed certain thresholds, sunlight, temperature and precipitation in orchards strongly deviate and potentially cause severe biotic and abiotic stress-related problems. Such events therefore influence management strategies, marketing, and revenues.

Analysis of weather in the 'Georgia Pecan Belt' indicates that patterns exist and that such patterns are predictable and appear to be regulated by the Southern Oscillation. Periods of exceptionally excessive rainfall and lack of rainfall are associated with these oscillations; therefore, disease, water, and sunlight management strategies and harvesting strategies are subject to alteration based on events transpiring several months previously. These data indicate that Oscillation events have the potential to be utilized as a tool to enable orchard managers to better protect orchards against weather anomalies.

319

CHESTNUTS IN NORTH AMERICA

Gregory Miller*, Empire Chestnut Company, 3276 Empire Rd SW, Carrollton, OH 44615

Prior to the 20th century, the American chestnut, native to the Appalachian region, was highly valued for its timber and sweet nuts. The introduction of chestnut blight, ca. 1900, has destroyed the species economically, but enough germplasm survives to resurrect the species, if blight can be overcome. Most research in the USA has focused on chestnut blight, neglecting other problems and opportunities, especially commercial production of exotic chestnut species. A large commercial industry does not yet exist in the USA, but does in other parts of the world. Blight-resistant exotic species could be cultivated as a high-value crop adapted to well-drained, acidic soils. In contrast to other nuts, chestnut kernels are low in fat and high in carbohydrate giving them unique culinary and food processing uses. Current problems are cultivar selection, propagation, insect pests, postharvest quality, and marketing.

## 145 WORKSHOP 14 (Abstr. 320–324)
## New Plant Growth Regulator (PGR) Activity and Research Opportunities for Peaches and Apples

320

BLOOM THINNING OF PEACH AND NECTARINE WITH MONOCARBAMIDE DIHYDROGENSULFATE

S. C. Myers, Department of Horticulture, University of Georgia, Athens GA 30602

Increased fruit weight, advanced fruit maturity, increased shoot growth and greater flower bud formation are positively related to thinning severity and timing. Thinning at bloom shows greatest effects. Although costly, hand removal is the primary thinning method. Chemical means have been used but have had disadvantages and/or lack of industry support. A new compound, monocarbamide dihydrogensulfate, has been used on apple. Trials conducted on 'Golden Queen' clingstone peach and 'Fantasia' nectarine in New Zealand and on 'Winblo' peach in Georgia suggest that this compound has significant potential for use in thinning stone fruit. An effective material rate (79-82% a.i. formulation) of 12 l/ha applied via airblast sprayer (calibrated delivery 1200 l/ha total volume) on peach resulted in a 56% reduction in flowers per limb cross-sectional area compared to unthinned controls when applied at full bloom. No phytotoxicity has been observed.

321

NEW THINNER CHEMISTRY FOR PEACHES AND APPLES

Ross E. Byers*, Department of Horticulture, Agricultural Experiment Station-Winchester, Virginia Polytechnic Institute and State University, 2500 Valley Avenue, Winchester VA 22601

Several classes of chemicals (auxins, cytokinins, gibberellins, ethylene releasing compounds, photosynthetic inhibitors, pollination inhibitors, and carbamates) have been found effective for reducing fruit numbers on apple and/or peach trees. The selection of a chemical for use as a commercial thinner is usually based on consistent effectiveness, freeness from fruit, leaf or tree injury, increases in fruit size, and low degree of environmental influences on fruit thinning or injury. In recent years research has been curtailed on newer chemicals due to the small and unique market, the costs of chemical registration, and non-support of the chemical industry due to potential law suits from over or under thinning. Recommendations that include the use of combinations, adjuvants or timings inconsistent with the existing label will likely become more difficult than in the past. Our results with Wilthin, YI1066, MYX6121, endothall and ammonium thiosulfate have been very positive as bloom thinners for peach. Further research is needed to determine which of these have the least injury for apples. In addition, we have considerable interest in Oxamyl and 6-benzyladenine for thinning apple fruit and their combinations with existing thinners and adjuvants.

322

NEW CHEMICAL THINNERS FOR APPLES

Duane W. Greene, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003-0062

Several new compounds show promise as chemical thinners. Benzyladenine (BA) has been identified as one of the most effective on apples. It is especially useful on McIntosh and Empire but it also thins other cultivars such as Delicious, Golden Delicious, and Idared. It is active at concentrations as low as 50 $mg \cdot liter^{-1}$. BA thins most effectively when applied at the 10mm stage of fruit development. It increases fruit weight indirectly by reducing crop load, but it can also increase fruit weight additionally and independently of its effect on crop load. BA frequently increases flesh firmness and soluble solids, but it must come in direct contact with the fruit to do this. Fruit treated with BA store comparably to similar sized fruit treated with other chemical thinners. There appears to be no unusual long term effects when BA is used as the only chemical thinner for several consecutive seasons.

323

CHEMICAL THINNER RESULTS ON 'GALA' AND 'FUJI' APPLES

Warren Micke*, Joseph Grant and James Yeager, Pomology Department, University of California, Davis, CA 95616

'Gala' and 'Fuji' apples are being extensively planted and are rapidly becoming important cultivars in California. 'Gala' requires early and precise fruit thinning to produce good size and quality fruit. Preliminary studies indicated that this cultivar might be relatively easy to chemically thin with a program similar to that used for the 'Granny Smith' cultivar in California. 'Fuji' is subject to severe biennial bearing and must be thinned early. However, previous research has shown it to be a difficult cultivar to chemically thin. High rates and/or combinations of materials showed promise of effective fruit thinning of 'Fuji' in limited trials in 1992, but not without phytotoxic effects of "pygmy" fruit, reduced fruit size and fruit russetting and marking. More extensive trials with both 'Gala' and 'Fuji' are planned for 1993 and preliminary results from these trials will be reported at this workshop.

324

MANAGING HIGH VIGOR IN BEARING ORCHARDS: CONTROLLING GROWTH WITH ETHEPHON

Ross E. Byers*, Department of Horticulture, Agricultural Experiment Station-Winchester, Virginia Polytechnic Institute and State University, 2500 Valley Avenue, Winchester VA 22601

Ethephon application at rates of 1000 ppm to 1500 ppm substantially inhibited tree growth but also caused fruit abscission. Application of gibberellin plus ethephon did not prevent fruit abscission. Low weekly doses of ethephon did not cause fruit abscission but gave good control of tree growth. Ethephon increased soluble solids and substantially reduced starch in the year of application. Flowering and fruit set were greatly increased by ethephon sprays the previous season. Fruit diameter or length:diameter ratios (L/D ratio) were not altered by



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the previous seasons' low weekly doses of ethephon.

Complete or partial loss of fruit in high density apple plantings can result in excessive shoot growth that is normally controlled by cropping. Spot spraying with ethephon in the top part of `Redchief Delicious'/MM. 26 trees for tree training purposes increased the number of shoots over 10 cm in the lower part of the tree, but also caused fruit abscission in the unsprayed parts of the tree. Summer training of high density plantings of fireblight susceptible varieties with spot sprays of ethephon would reduce the need for cutting or pinching branches during the tree growth period.

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TEACHING PLANT PHYSIOLOGY AND MORE WITH WISCONSIN FAST PLANTS®

Pablo Jourdan, Department of Horticulture, The Ohio State University, Columbus, OH 43210-1096

Budgetary, logistical and time constraints frequently limit the extent of hands-on activities included in introductory courses in horticulture. Model organisms can facilitate the demonstration of broad-based principles and enhance learning. The Wisconsin Fast Plants®, rapid cycling forms of *Brassica rapa*, represent such a model organism with diverse and useful applications in horticultural instruction. These organisms offer not only a practical advantage for teaching, but also facilitate learning at higher levels of thinking because they permit integration of concepts at the molecular, organismal, and population levels. A large collection of educational activities is currently available with these plants that can be used to enhance understanding of basic botanical principles; many aspects of plant physiology; broad principles of crop production; genetics and plant breeding; and molecular manipulations. The educational strategy afforded by these plants will be described.

## 146 WORKSHOP 15 (Abstr. 326–327) Model Plant Systems for Teaching Horticultural Science

326

TEACHING MENDELIAN GENETICS WITH TOMATO SEEDLING MUTANTS

E.C. Tigchelaar, Department of Horticulture, Purdue University, 1165 Horticulture Building, West Lafayette, IN 47907-1165

The tomato rivals the fruit fly as a convenient species for genetic research. As an important and familiar food crop, the tomato is also a useful species to demonstrate application of the principles of genetics for crop improvement.

Fifteen unique seedling mutants which are expressed during the first 2-3 weeks of seedling growth have been selected to illustrate genetic variation and to demonstrate the common principles of genetics. Appropriate markers have been used in crosses to demonstrate segregation, lethal genes, independent assortment, repulsion and coupling phase linkage, epistasis, and random chromosome and chromatid segregation). F2 populations segregating for as many as seven marker genes have been developed to illustrate gene interaction and to demonstrate the remarkable variation possible even with a small number of segregating gene pairs. Unknown populations may also be used to challenge students to independently analyze an unknown population for two or more of the 15 seedling marker genes chosen. A small greenhouse or laboratory bench with growing lights will provide adequate space for each exercise.

327

TEACHING PLANT TISSUE CULTURE TECHNIQUES AND EXPERIMENTS

Marihelen Kamp-Glass, Department of Plant Science, North Carolina A&T State University, Greensboro, NC 27411-1087

With the expansion of agriculture biotechnology, plant biotechnology has become increasingly popular as a means of producing commercially useful crops for consumption and research. The ability to perform research on crops requires a basic understanding of the techniques of plant cell and tissue culture for genetics and other areas of plant physiology and horticulture. Teaching basic plant tissue culture techniques such as aseptic techniques, media preparation, explant orientation, callus induction and embryo culture will be discussed.

## 147 WORKSHOP 16 (Abstr. 328–332) Multi-level Interactions between Cover Crops and Perennial Fruits

328

DAMAGE-ACTION THRESHOLDS FOR WEEDS IN NEWLY PLANTED APPLE ORCHARDS

Ian Merwin,* Department of Fruit and Vegetable Science, 118 Plant Science Building, Cornell University, Ithaca, NY, 14853

The development and implementation of economic damage thresholds have helped to reduce insecticide and fungicide usage in fruit production. However, herbicides are still routinely applied by calendar date in orchards, because damage-action thresholds have not been established for weeds. For two years we have evaluated different temporal and spatial combinations of tree-row weed suppression in a newly planted apple orchard. Tree growth, nutrient uptake and groundcover species mixtures have been analyzed yearly. Observations to date indicate that the timing of weed suppression was more critical than the area, in both wet (1992) and dry (1991) summers. Few significant differences were observed comparing tree growth or nutrient uptake in 2, 4 or 6m$^2$ weed-free tree-row plots. Early summer weed control appeared to be more beneficial than mid- or late-summer control during both years. Grasses became dominant in early summer treatments, while broadleaf weed cover increased in late summer treatments. These observations indicate that treating a narrow band with post-emergence hebicides may be sufficient to ensure adequate apple tree establishment in some sites.

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FLOWERING PLANTS AS RESOURCES FOR NATURAL ENEMIES OF APPLE PESTS IN ORCHARDS

D. Matthews-Gehringer, E. Lachowski, T. Schettini* and R.L. Bugg, Rodale Institute Research Center, 611 Siegfriedale Road, Kutztown, PA 19530 and Sustainable Agricultural Research and Education Program, University of California, Davis, CA 95616.

To obtain preliminary information on what flowering plant species are suitable to provide pollen, nectar and shelter for natural enemies of apple pests, six plant species were evaluated in a one-acre orchard in PA for their habitat potential. Sweepnet samples revealed that peak arthropod population densities were collected during peak bloom periods which varied for each plant species. The highest densities of Parasitic Hymenoptera and Insidious Flower Bugs (natural enemies) were found on Buckwheat, Mustard and Queen Anne's Lace, and lower densities on Anthemis, Black-Eyed Susan and Showy Goldenrod. Tarnished Plant Bug (apple pest) population trends were similar. Management of flowering ground covers for orchards should balance providing optimum resources for natural enemies without encouraging apple pest populations.

330

USE OF COVER CROPS FOR WEED MANAGEMENT IN GRAPE AND TREE FRUITS.

C.L. Elmore*, R.J. Smith, E. Weber and R. Miller, University of California, Davis, Santa Rosa, Napa and Davis, CA.

Weeds are found throughout the orchard or vineyard floor. They are controlled mostly in a band down the tree or vine row with cultivation, or more frequently with one or more applications of one or more herbicides. Instead of resident vegetation, planted cover crops of choice are being planted to "control" the vegetation. Two aspects of cover crops for weed control have been studied. First, the selective herbicides, sethoxydim, fluazifop, 2,4-D and combinations have been applied to selectively shift plant species within the vineyard to more desirable cover crops. Secondly, cover crops have been planted into prepared soil, grown for biomass, chopped and transferred as a mulch to the tree or vine row. A mixture of cultivated oat, purple and common vetch grown between the rows, chopped and blown into clean soil under trees or vines has effectively controlled annual weeds. The quantity of cover crop biomass produced is critical for adequate weed control.



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**ORCHARD GROUND COVER MANAGEMENT AFFECTS TREE FRUIT PRODUCTION**

Walter A. Skroch, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

**Studies indicate that growth of apple and peach trees and yield of apple fruit is affected by ground cover management. Living ground covers compete with trees for water and nutrients, but bare ground (clean culture) results in soil compaction, increased runoff and erosion, and poor maneuverability of equipment. Competition between orchard trees and living ground covers is a factor in tree growth, timing of the first crop year, and fruit yield and quality. Certain grasses tend to be more competitive than broadleaf ground covers. Cool-season grasses (bluegrass, orchardgrass, tall fescue) under Red Delicious and Golden Delicious apples were shown to reduce soil moisture levels, reduce fruit yield and size, and delay fruit maturity. Various vegetative ground cover systems (strip cover, cover crop, herbicide no-till) and ground cover types can be utilized to reduce soil erosion and maintain soil structure, while at the same time reduce competition with trees and optimize crop yield and quality.**

332

EFFECT OF BARE GROUND, ALL GRASS, OR ALL BROADLEAF GROUND COVERS ON BIOLOGICAL MITE CONTROL AND ON TREE GROWTH AND PRODUCTIVITY

William M. Coli, Department of Entomology, Agricultural Engineering Building, University of Massachusetts, Amherst, MA 01003

As a component of a large, interdisciplinary study of Biointensive Integrated Pest Management, the composition of orchard ground covers and woody borders was characterized in 28 Massachusetts commercial apple orchards, and plants which were most likely to harbor Tetranychid spider mites and Phytoseiid mite predators was determined. Data are presented on makeup of plant communities within orchards and adjacent woody borders. All species of spider mites and mite predators were more often observed on broadleaf plants than on grasses.

In 1989, two 1-Acre orchard blocks were established to compare the effect of of either bare ground, an all grass row, or an all broadleaf row ground cover on phytophagous and predatory mite population dynamics, and on tree growth and productivity. Data are presented on frequency of occurrence of mites found in timed scans, and on differences in trunk circumference increase in each ground cover regime.

## 148 WORKSHOP 17 (Abstr. 333–336) Postharvest Physiology and Packaging of Small Fruits

333

PHYSIOLOGY OF RIPENING IN BERRY CROPS

Michael Knee*, Department of Horticulture, The Ohio State University, 2001 Fyffe Court, Columbus, OH 43210-1096

Botanically, "berry crops" are not a homogeneous group, or distinct from other horticulturally defined groups of fruits. Many horticultural "berries" are not berries in a botanical sense and they originate from as wide a variety of floral structures as other fleshy fruits. Nevertheless there are many similarities in fruit development and physiology among horticultural berries and between these and other fruits. An early phase of cell division is followed by cell enlargement, with concomitant accumulation of sugars and organic acids. In the ripening phase, chloroplast to chromoplast transitions, accumulation of vacuolar pigments and cell wall alterations are general phenomena. The climacteric pattern of ripening and regulation by ethylene have attracted most attention in the literature on fruit ripening; this may be appropriate for tree fruits, but many berries are non-climacteric and we have to consider other regulatory mechanisms. Similarly, although cell wall degradation by polygalacturonase has captured attention in other fruits, other softening mechanisms need to be considered for fruits, such as strawberry.

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MAP OF BLUEBERRY FRUIT: EFFECT OF TEMPERATURE AND $CO_2$ ON PACKAGE $O_2$ AND THE RQ BREAKPOINT

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

The respiratory behavior of blueberry (Vaccinium corymbosum L. 'Bluecrop') fruit was determined under a variety of conditions using a modified-atmosphere packaging (MAP) approach. In each case, $O_2$ and $CO_2$ partial pressure gradients across the film were used to calculate rates of $O_2$ uptake, $CO_2$ production and the respiratory quotient (RQ). The effects of temperature and $O_2$ partial pressure on $O_2$ uptake, $CO_2$ production and the RQ were characterized. The steady state $O_2$ partial pressure at which the fruit began to exhibit anaerobic $CO_2$ production (the RQ breakpoint) increased with increasing temperature from approximately 2 kPa $O_2$ at 0C to 4.5 kPa $O_2$ at 25C. It was determined that the energy of activation of $O_2$ permeability for a film needed to be approximately 60 kPa to maintain $O_2$ levels at or above the RQ breakpoint across this temperature range. RQ was also dependent on $CO_2$ levels. As $CO_2$ partial pressure increased, the RQ breakpoint increased. The lower $O_2$ limit was estimated to be 6, 7, 11 and 23 kPa $O_2$ for 5, 20, 40 and 60 kPa $CO_2$, respectively, at 15C.

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LOW DOSE γ-IRRADIATION AND MODIFIED ATMOSPHERE PACKAGING EFFECTS ON QUALITY AND MICROFLORA CHANGES IN BLACKBERRIES

M.M. Barth*, B.E. Langlois, R. C. Christenson
Departments of Nutrition and Food Science, Animal Sciences, Radiation Sciences, University of Kentucky, Lexington, KY 40506-0054

Increased interest has been demonstrated in the production and marketing of thornless blackberries. Once blackberries are harvested, the length of time they can be stored at low temperatures above freezing is limited by initiation of fungal spoilage and rapid loss of market quality. The objective of this study was to assess effects of low dose γ-irradiation and modified atmosphere packaging on market quality retention of thornless blackberries as evaluated by Hunter color values, Instron shear rates, TSS, pH, and microbial growth over 96 h. Blackberries were irradiated at ambient temperatures using a Nordion Gammacell Model 220 (dose rate = 11.0 Grays/min) delivering a 0.3 kGy dose to the tissue. Both control and irradiated samples were placed in packaged and nonpackaged groups, stored over 96 h (4°C), taken for analysis at 24 hr intervals. An additional treatment included packaged controls containing $C_2H_4$ absorbant. Following 72 h storage, packaged samples were stored in air to determine subsequent benefit. $CO_2$ and $O_2$ concentrations inside packages were 7.5% and 11.6%. By 72 hr, yeast and mold counts were lower in irradiated, packaged samples, but a significant increase was observed following placement of samples in air.

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TOLERANCE OF STRAWBERRIES TO LOW $O_2$ AND/OR HIGH $CO_2$ ATMOSPHERES

Adel A. Kader*, Dept. of Pomology, University of California, Davis, CA 95616

Controlled atmospheres (CA) with low $O_2$ and/or high $CO_2$ concentrations are effective in maintaining quality and extending the postharvest life of strawberries. The efficacy of CA in controlling decay and insects (to meet quarantine requirements) requires $O_2$ levels below 1% and/or $CO_2$ levels above 15%. The tolerance of strawberries to such fungicidal and/or insecticidal CA depends upon the cultivar, temperature, and duration of exposure. Development of alcoholic off-flavor is the main detrimental effect of low $O_2$ and/or high $CO_2$ stresses and is associated with accumulation of ethanol and ethyl acetate due to increased activities of alcohol dehydrogenase and acetyl CoA alcohol transferase. Strawberries tolerate exposure at 0 or 5°C to 0.5 or 0.25% $O_2$ (balance $N_2$) for 10 days, air + 20% $CO_2$ for 10 days, or air + 50% or 80% $CO_2$ for 6 days before alcoholic fermentation and other injury symptoms become objectionable. Keeping strawberries in non-injurious CA has positive residual effects on their flesh firmness, color, and composition after transfer to air.

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# 160 ORAL SESSION 39 (Abstr. 337–344)
## Fruit (Subtropical): Culture and Management

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OLIVE FRUIT LOOSENING WITH PHOSPHORUS
George C. Martin* and Chic Nishijima, Department of Pomology, University of California, Davis, CA 95616-8683

Under laboratory conditions foliar sprays of $NaH_2PO_4$ to olive explants induce fruit loosening with low percent leaf loss. In the field, $NaH_2PO_4$ foliar sprays are less successful in fruit loosening. Trunk injections of $NaH_2PO_4$ to olive trees in the field result in both leaf and fruit abscission. The lack of fruit abscission inducement from foliar sprays is thought to be due to poor chemical penetration. To improve penetration of $NaH_2PO_4$ several additives were tested to slow drying rate. These treatments led to increased fruit abscission over that of $NaH_2PO_4$ used without an additive. Even more fruit abscission was achieved with $H_3PO_4$ but this treatment led to fruit marking. Several additives were mixed with $H_3PO_4$ in addition to pH adjustment to ameliorate the fruit marking problem. The best current treatment combines $H_3PO_4$ with adjuvants such as Regulaid or Activator 90. It appears that adjuvant reduction of surface tension results in $H_3PO_4$ spread over more fruit surface, inducing less fruit making, while retaining the fruit abscission inducement feature desired.

338
RECLAIMED WATER FOR CITRUS: EFFECTS OF IRRIGATION RATE ON TREE GROWTH AND YIELD.
T. Adair Wheaton and Larry R. Parsons*, University of Florida, CREC, 700 Expt. Sta. Rd., Lake Alfred, FL 33850

This study was designed to determine the effects of different irrigation rates with reclaimed water on citrus tree growth and yield. High application rates (1270 and 2540 mm per year) of highly treated reclaimed water were compared to a recommended rate of 406 mm per year of reclaimed or well water. Greater irrigation significantly increased tree growth and fruit yield. Canopy volume at the 2540 mm rate was 55% greater than the 406 mm rate. With Hamlin orange and Orlando tangelo, fruit yields at the highest rate were 39 and 71% greater, respectively, than the lowest rate. Soluble solids were diluted at the higher irrigation rates, but total production of soluble solids per hectare was significantly greater at the high irrigation rates. Yield response was greatest at the high irrigation rate with Swingle citrumelo rootstock. On deep sands, high irrigation rates can improve tree growth and yield in a humid region.

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FREEZE DAMAGE, PRUNING, AND YIELD RECOVERY OF RIO RED GRAPEFRUIT IN TEXAS

John E. Fucik, Texas A&I University Citrus Center, P.O. Box 1150, Weslaco, Texas, 78596.

Following the 1989 Christmas freeze, 4 year-old Rio Red grapefruit trees were rated for freeze damage and given 9 pruning treatments, ranging from the non-pruned controls to removing the canopy and most of the trunk. Wound dressing with and without a fungicide was used with some treatments. One set of trees was pruned in March, and a second in May, 1990. Each treatment had 6 single-tree reps. The pruning treatments were evaluated with respect to the fruit harvested, by canopy location, in 1992-93 and the severity of freeze damage.

Severe pruning resulted in smaller fruit than the controls, which was most likely due to the inverse relationship of size to number of per unit of canopy. Fruit size from May-pruned trees was consistently smaller than that from trees pruned in March. The wound dressings and fungicides had no effect on yields or fruit size. Except for the trees which died, the severity of freeze damage was not a good predictor of yield recovery.

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HURRICANE ANDREW DAMAGES TROPICAL FRUIT CROPS IN SOUTH FLORIDA
Richard Campbell[1]*, Carl Campbell2, Jonathan Crane[2], Carlos Balerdi[3] and Seymour Goldweber[3] [1]Fairchild Tropical Garden, 11935 Old Cutler Rd., Miami, Fl. 33156;
[2]University of Florida - TREC, 18905 S.W. 280 St., Homestead, Fl. 33031;
[3]Dade County Cooperative Extension Service, 18710 S.W. 288 St., Homestead, Fl. 33030

On 24 August, 1992, Hurricane Andrew struck South Florida's tropical fruit production area with sustained winds of 230 kph and gusts exceeding 280 kph. Damage included defruiting, defoliation, limb and trunk breakage, windthrowing (uprooting), sunburning and the stripping of bark from the trunks and limbs by flying debris. In general, older and taller trees were more severely damaged than younger and shorter trees. Selective limb removal, topping and other pruning practices that reduced overall tree height and opened up the canopy greatly reduced the occurrence of windthrow and severe breakage. Severe damage occurred on lime, mango, passion fruit, lychee and longan; damage was moderate on atemoya, avocado, banana, mamey sapote, papaya and sugar apple; and light damage occurred on carambola and guava. The full extent of injury cannot yet be determined as additional losses will occur due to the direct trauma of the hurricane, insects and diseases, cold temperatures and drought.

341
ASPECTS OF POLLINATION IN *HYLOCEREUS*, A CACTUS NEWLY INTRODUCED TO THE NEGEV DESERT OF ISRAEL
Julia Weiss[1]*, Avinoam Nerd[2] and Yosef Mizrahi[1,2] 1. Department of Life Sciences and 2. The Institutes for Applied Research, Ben Gurion University of the Negev, Beer-Sheva, Israel.

*Hylocereus* is a night-flowering cactus, whose hermaphrodite flowers reach a diameter of 22 cm. It was found in early studies that both self-fertility and self-sterility occur among the 14 species introduced to Israel. Flowers of all species behaved similarly concerning the phenology of flower opening and closing. Flowers opened about 1 hr. before sunset and were completely closed at approximately 6 hrs. after sunrise. Hand-cross-pollination led to 100% fruit set until 24 hrs. after flower opening, after which time both stigma receptivity and pollen germinability declined. Crossings between species bearing red fruits led to a higher fruit weight (424±134 g) in comparison to crossings between red-fruited species and species with yellow spiny fruits (146±64 g). Pollen germination *in vitro* for red-fruited species ranged from 23 to 59% but was only 0.7% for yellow-fruited species. To test the effectiveness of the honey bee as a pollinator a beehive was placed inside a nethouse. The flowers were visited by bees mainly in the morning; the bees foraged on pollen and eventually touched the stigmata of the flowers. Both the regularity of bee visits and the percentage of fruit set after bee visitation was very low (19%). This might be due to the fact that flowers were not constantly available; therefore the bees did not accept them as a constant and reliable pollen source.

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PESTICIDES TOXICITY ON POLLEN GERMINATION OF 'HADEN' MANGO (*Mangifera indica* L.)
Zen-hong Shu, Fengshan Tropical Horticultural Experiment Station, TARI, Fengshan, Kaohsiung, Taiwan, 83017 R. O. C.

It has been speculated for many years that crop yield diminution may be due to the possible adverse effects of pesticidal sprays during the blooming period on pollen germination and fruit set. To realize the toxicity of pesticides on the reproductive physiology of mango, pollen germination, both *in vitro* and *in vivo* , under the constrain of pesticides were conducted. The results showed that among all the pesticide tested, Lannate and Tamaron were the least toxic ones to mango pollens germinated on agar medium incorporated with pesticides. Pesticides when sprayed on the surface of germination medium had strong adverse effect on pollen germination. Except for Tamaron, the fertilization of mango flowers were extremely sensitive to pesticidal sprays 2 hours before or 4 hours after hand pollination. Fertilization and initial fruit set were not or less influenced by pesticides for flowers sprayed 24 hours after pollination.

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LOSSES IN FRUIT YIELD DUE TO MANGO MALFORMATION.
M.Ibrahim * ,S.A.Anwar. A.Khan
Agric. Biochemistry,Ayub Agric.Res.Instt.Faisalabad,Pakistan.

Mango malformation is one of the major factors causing significant fruit loss in Pakistan. To investigate the role of malformation a long-term field experiment was established on 15 years old mango orchard. Malformation



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inflorescences were removed and counted in last week of April and fruit were harvested in July every year starting from 1989.Malformed inflorescence varied from plant to plant however, during 1990, 1991 and 1992 it decreased considerably over the control year (1989). The malformation was 77% during control year 1989, 57% during 1990, 57% during 1991 and 50% during 1992. Mango fruit yields were significantly decreased due to non-bearing malformed inflorescences. The mean yield decrease was 83 % during 1989 which relatively improved in later years and were 58% in 1990, 53% in 1991 and 54% in 1992.

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THE EFFECT OF GIBBERLLIN AND SOME MICRO NUTRIENTS SPRAYS ON YIELD AND FRUIT QUALITY IN CAVENDISH BANANA (MUSA CAVENDISHII)

Ahmed M. Akl, Adb El-Fattah M. Eid, and S.M. Mohamed, Dept. of Hort., Fac. of Agric., Minia Univ., Ministry of Agric., Souhag, Egypt

The present study was carried out during 1984/85 and 1985/86 to investigate the effect of four gibberellin acid concentrations (0.0, 25, 50, and 75 ppm) and five micro-nutrients treatments (no micro nutrients, copper, zinc, manganese and the three nutrients together) as well as the combination between them on the yield of Mindy banana plants and fruit physical and chemical properties. Under the conditions of this experiment the results indicated that the treatments contained gibberellin acid at 50 or 75 ppm and mixture of copper, zinc, and manganese significantly increased the yield of Mindy banana plants and improved fruit physical properties; however, fruit chemical constituents were somewhat inferior.

# 161 ORAL SESSION 40 (Abstr. 345–352) Cross-commodity: Biotechnology/Cell and Tissue Culture

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SIMPLIFIED CONSTRUCTION AND PERFORMANCE OF A DEVICE FOR PARTICLE BOMBARDMENT

D. J. Gray[1]*, E. Hiebert[2], M. E. Compton[1], C. M. Lin[2] and D. W. McColley[1], [1]Central Florida Research and Education Center, University of Florida-IFAS, 5336 University Ave., Leesburg FL 34748 and [2]Plant Pathology Department, 1453 Fifield Bldg., University of Florida-IFAS, Gainesville, FL 32611

Design modification of a particle inflow-type gun for particle bombardment significantly simplifies construction and reduces fabrication time. The gun consists of a high-speed electric solenoid valve mounted on and through a vacuum jar. DNA-coated tungsten particles are placed on the support grid of a filter housing and accellerated by a burst of pressurized helium, which is controlled by a timer. Specimens are held between plastic screens and their distance from the particle support grid is adjusted with a miniature laboratory apparatus positioner. Transient expression of GUS in cantaloupe cotyledons and grape somatic embryos was equivalent to that obtained with a conventional particle inflow gun. The device was constructed with locally-available hardware in 40 minutes using a hand drill, some thread taps and a thread die.

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EXPRESSION OF THE β-GLUCURONIDASE GENE IN WATERMELON COTYLEDON EXPLANTS FOLLOWING PARTICLE BOMBARDMENT OR INFECTION WITH *AGROBACTERIUM TUMEFACIENS*.

Michael E. Compton[1]*, D.J. Gray[1], E. Hiebert[2] and C.M. Lin[2]. [1]CFREC-IFAS, University of Florida, 5336 University Ave., Leesburg, FL 34748 and [2] Plant Pathology Dept., 1453 Fifield Bldg., University of Florida, Gainesville, FL 32611-0513.

Cotyledon explants were established from 5- to 6-day-old 'Minilee' seedlings germinated on MS medium with 2% sucrose and 0.7% TC agar, and precultured for 2 days on modified MS as above but with 3% sucrose and 5 μM BA before bombardment. Plasmid DNA [pUC221 and pUC472, which contain the β-glucuronidase (GUS) and NPTII (kanamycin resistance) genes, respectively] was delivered to the explants using a modified particle inflow gun following precipitation on to 1.1 μm tungsten particles. Explants infected with *Agrobacterium* (strain LBA4404 with the binary vector pBI121, which contains genes for GUS and kanamycin resistance) were not precultured prior to co-cultivation for 4 days. GUS expression was measured 1 week after transfer to selection medium. Infection with *Agrobacterium* was the best method for delivering foreign DNA to watermelon cotyledons. Up to 300 GUS-expressing colonies were observed per explant following infection with *Agrobacterium* compared to 128 after bombardment.

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CALLUS INDUCTION IN 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.

The effect of auxins and cytokinins on callus induction in garlic was investigated. Young basal plate leaf explants of one genotype were grown on a modified B5 medium supplemented with 50 hormone combinations in a complete factorial design. The best callus growth occurred on media supplemented with 2,4-D (compact-not friable) or picloram + 2iP (friable with some shoot production). These two hormonal treatments were applied to 5 different garlic genotypes. After 10 weeks, callus was transferred to the other hormonal treatment. The best induction of friable callus occurred when explants were initially cultured on media with 2,4-D and then subcultured on media with picloram + 2iP. This friable callus is being evaluated for developing suspension cultures and a genetic transformation system.

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EXPRESSION OF THE GUS GENE IN *AGROBACTERIUM TUMEFACIENS*-TRANSFORMED SPINACH PLANTS

J.M. Al-Khayri*, R.W. Miles, F.H. Huang, T.E. Morelock, and J.McD. Stewart, Department of Horticulture and Forestry, and Department of Agronomy, University of Arkansas, Fayetteville, AR 72701.

Transgenic spinach (*Spinacia oleracea* L., cv. High Pack) plants were regenerated from callus derived from hypocotyl segments. Explants were cocultivated for 48 h with *Agrobacterium tumefaciens* harboring pMON 9749 plasmid conferring kanamycin resistance and β-glucuronidase (GUS) activity. To induce callus, the explants were cultured on Murashige and Skoog (MS) selective medium containing 2 mg $L^{-1}$ kinetin and 0.5 mg $L^{-1}$ 2,4-D. Shoots developed from the callus upon transfer to selective regeneration medium supplemented with 2 mg $L^{-1}$ kinetin, 0.01 mg $L^{-1}$ 2,4-D, and 1 mg $L^{-1}$ $GA_3$. Shoots were rooted on MS medium containing 1 mg $L^{-1}$ IBA. Excluding the cocultivation medium, all others were supplemented with 50 mg $L^{-1}$ kanamycin, 100 mg $L^{-1}$ cefotaxime, and 100 mg $L^{-1}$ carbenicillin. To confirm transformation, kanamycin-resistant callus and leaf sections from regenerants were assayed for GUS activity using the X-gluc assay. Stable GUS gene expression in transgenic plants was demonstrated. This is the first report of regenerating transformed spinach.

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CHROMOSOME DOUBLING OF INTERSPECIFIC $F_1$ HYBRIDS BETWEEN *Allium fistulosum* x *A. cepa* THROUGH COLCHICINE TREATMENT OF REGENERATING CALLUS

Ping Song*, Wanhee Kang, Ellen B. Peffley, Department of Agronomy, Horticulture & Entomology, Texas Tech University, Lubbock, TX 79409-2122

Regenerating calli of *Allium fistulosum* x *A. cepa* interspecific $F_1$ hybrids were treated *in vitro* with colchicine. A factorial experiment (colchicine concentration x time) was used to recover tetraploids from *in vitro* colchicine treated calli. Shoot production of regenerating calli following *in vitro* colchicine treatment decreased with increasing colchicine concentration and treatment time. Cytological analyses of root tip cells from regenerated plantlets showed that chromosomes of control plantlets (not treated with colchicine) were not doubled. Chromosomes of some plantlets regenerated from *in vitro* colchicine treated calli were doubled, resulting in tetraploids. Calli treated with 0.1 or 0.2% colchicine in BDS (Dunstan & Short, 1977) liquid medium for 48 or 72 hours yielded the highest number of tetraploid plantlets. These results demonstrate that *in vitro* colchicine treatment of regenerating calli of interspecific $F_1$ hybrids is effective in recovering tetraploids.



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**DEVELOPMENTAL REGULATION OF PROTEINS IN ZYGOTIC- AND SOMATIC EMBRYOS OF PECAN.**

Benjamin Jeyaretnam*[1], Hazel Y. Wetzstein[1] and Sharad C. Phatak[2]
Department of Horticulture, University of Georgia, [1]Athens, Ga 30602 and [2]Coastal Plain Experiment Station, Tifton, Ga 31793.

Soluble and insoluble proteins from pecan (Carya illinoensis) zygotic and somatic embryos were resolved on one dimensional SDS-PAGE to study the changes in expression patterns of proteins. Soluble proteins were extracted using 0.1M NaCl and 50 mM Tris-HCl buffer while insoluble proteins were recovered by treating the pellet with SDS in Tris-HCl buffer. Several new insoluble proteins appeared during early maturation (26-47 days post anthesis, DPA) of zygotic embryos. The insoluble protein profile from early somatic embryos resembled that of cotyledon expansion stage zygotic embryos. About 12 groups of insoluble proteins are abundantly expressed after 27 DPA in zygotic embryos and constitute major storage and structural proteins. In contrast, storage proteins were absent in all somatic embryo stages. The intensity and number of bands of zygotic embryo soluble proteins declined with maturation and 11 prominent groups appeared around post-abscission stage.

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DIRECT SOMATIC EMBRYOGENESIS FROM PROTOPLASTS DERIVED FROM EMBRYOGENIC SUSPENSION CULTURES OF ASPARAGUS OFFICINALIS L.

Roger A. May* and Kenneth C. Sink, Department of Horticulture, Michigan State University, East Lansing, MI 48824, U.S.A.

Embryogenic callus from four asparagus genotypes (JG8, MD10, MD22, and 86SOM1) was initiated from micropropagated spears placed on semisolid LS medium containing 5 $\mu$M 2,4-D or 50 $\mu$M NAA, concomitantly. After three subcultures such cells were used to initiate suspensions in liquid medium of the same composition. The eight sets of suspensions were used as sources of protoplasts at two months of age and again at five months. Protoplasts were immobilized at $10^5$/ml density in MS medium with 0.6% agarose and overlaid with liquid KM medium containing the auxin of the corresponding donor suspension or no hormones. Plating efficiencies were recorded at 14 days and ranged from 0% to 40% depending on the genotype, suspension medium, and inclusion or exclusion of hormones in the protoplast plating medium. All four genotypes were capable of forming somatic embryos directly from protoplasts; however, conversion was greatest from MD10 and MD22 derived cultures and occurred as rapidly as six weeks after initial protoplast culture.

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REGENERATION IN VITRO OF CUCUMBER (CUCUMIS SATIVUS L.) CULTURED FROM EXCISED SEEDS AND COTYLEDONS

Karim H. Al-Juboory*, University of Baghdad, College of Agriculture, Department of Horticulture, Abu-Ghraib, Baghdad, Iraq

Seed and cotyledon explants of 'Al-Mokhtar' hybrid (a new cultivar of cucumber) were prepared and disinfected. Explants were transferred to modified Murashige and Skoog (MS) medium supplemented with a combination of 6-benzylaminopurine (BA) and napthaleneacetic acid (NAA). Shoots regenerated best on medium supplemented with $\geq$ 2.0 mg/l BA. The BA concentration significantly interacted with NA with respect to shoot regeneration.

# 162 ORAL SESSION 41 (Abstr. 353–357)
## Cross-commodity: Temperature Stress

353
FOLIAR AND ROOT HEAT TOLERANCE OF THREE CONTAINER-GROWN HOLLIES

John M. Ruter*, Horticulture Dept., University of Georgia, Coastal Plain Experiment Station, Tifton GA 31793

The membrane thermostability of *Ilex cornuta* Lindl. & Paxt. 'Needlepoint' (Chinese holly), *Ilex aquifolium* L. 'Albo-marginata' (English holly) and *Ilex* x 'Nellie R. Stevens', a hybrid between *Ilex aquifolium* and *Ilex cornuta*, was determined using electrolyte leakage procedures with excised foliage and root tissue. The critical midpoint heat-killing temperature ($T_m$) after a 30 min exposure for the foliage of 'Nellie R. Stevens' (54.4$\pm$0.4) was approximately 1C greater than for Chinese (52.9$\pm$0.3) or English holly (52.9$\pm$0.4). The $T_m$ for root tissue of English holly was higher (53.9$\pm$1.5) than either 'Nellie R. Stevens' (51.7$\pm$0.3) or Chinese holly (50.1$\pm$0.3). The results of this study suggest that English holly can withstand the same or a greater degree of direct heat injury compared to Chinese holly. The poor performance of English holly in the southeastern United States is suggested to be its inability to withstand prolonged but sublethal high temperatures which do not cause direct membrane injury.

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STARCH ACCUMULATION AND GROWTH OF *RHODODENDRON CATAWBIENSE* IN RESPONSE TO DAY/NIGHT TEMPERATURE

D.B.Rowe*, S.L.Warren, F.A.Blazich, and D.M.Pharr. Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Seedlings of *Rhododendron catawbiense* Michx. were grown for 20 weeks under long day conditions with days at 18, 22, 26, or 30C for 9 hours with nights at 14 or 22C for 15 hours. Net leaf photosynthetic rates and exported carbohydrates increased with increasing day and night temperatures. Days of 22C and nights of 14C resulted in the highest starch levels. The greatest increase in daily starch accumulation occurred at days of 22C with considerably less starch accumulation at days of 30C. In plants grown at nights of 14C, the greatest daily increase in starch occurred at days of 18 and 22C. In contrast, for plants grown at nights of 22C, the greatest starch accumulation occurred at days of 26 and 30C. Photosynthetic rates and starch levels coincided with overall plant growth. Maximum total plant dry weights occurred at day/night temperatures of 22/22C with minimum levels at 30/14C.

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INFLUENCE OF Fe CHELATES AND pH ON HEAT-INDUCED CHLOROSIS IN SEEDLINGS OF HONEY LOCUST

William R. Graves*[1], and Carrie E. Green[2]
[1] Dept. of Horticulture, Iowa State Univ., Ames, IA 50011
[2] Dept. of Horticulture, Univ. of Maryland, College Park, MD 20742 & Environmental Chemistry Lab, USDA-ARS, Beltsville, MD 20705

We observed previously that a root-zone temperature (RZT) of 34C caused severe chlorosis of *Gleditsia triacanthos* L. var. *inermis* Willd. (thornless honey locust) grown in solution. To determine whether the form of Fe chelate or the solution pH influence chlorosis, we measured growth, chlorophyll (Chl) content, and essential elements in solution-cultured seedlings treated with different chelate forms (Fe-EDTA, Fe-EDDHA, or no Fe), pH (5.4 or 7.0 upon weekly replacements), and RZT (23 or 34C). Chelate form and pH did not affect the development of chlorosis. Reductions of at least 50% Chl were induced by high RZT. Concentrations of P, Mg, Zn, Mn, and Fe in lamina were affected by RZT. Fe treatments caused Mg, Zn, Mn, Cu, and Fe concentrations to differ. Solution pH increased between replacements even in solutions without Fe, indicating that Fe-deficiency responses in this species merit further attention.



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FLORAL BIOLOGY AND FRUIT SET OF SOME CITRUS SPECIES AND CULTIVARS IN RELATION TO HEAT AND DROUGHT STRESSES

Samir Z.El-Agamy* and Mohamed A.Shaheen, Fac. of Agriculture Assiut University, Assiut, Egypt and Faculty of Meteorology, P.O Box 9034, Jeddah, Saudi Arabia.

Floral biology of 8 citrus species and cultivars including orange (Valencia, Hamlin, Temple and Navel), tangarine (Dancy), lemon (Lisbon) and grapefruit (Marsh and Ruby) was studied on trees grown in extreme high temperature and drought. Measurement: included flowering date,duration and type, pollen viability, diameter and germination (using fluorescent microscope), initial and horticultural fruit set and fruit drop percentage and fluctuation. No significal correlation was found between initial fruit set and pollen viability (except in Marsh grapefruit). Horticultaral fruit set percentages were generally less than 0.5 in all species except in tangaring and lemon.

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LANDSCAPING THE DESERT OF KUWAIT

Mahdi S. Abdal*, and Mohamed S. Albahouh. Aridland Agriculture Department, Kuwait Institute for Scientific Research, P.O.Box 24885, Safat 13109, Kuwait.

The Climate of Kuwait is characterized by hot and dry summers with frequent sandstorms, and mild winters with low rainfall. Soils are generally sandy in texture. Water supplies are particularly limited and all ground water resources are extremely brackish with an average total dissolved solids (TDS) content of 4500 mg/l. Trickle system is the major method used for irrigation. Lack of water is the main limiting factor in Kuwait. High temperature is another factor causing increased evaporation. Such evaporation brings soluble salt to the soil surface and forms saline soils. Salinity is further elevated by the use of brackish water in irrigation. There have been many ways to alleviate this problem, but the most important approach practiced has been to carefully select plant species that are saline and heat tolerant. Tests have been carried out to establish the tolerance of numerous species,under conditions of brackish (3500-4500 mg/l) water irrigation and high temperatures. Lists of some of the plant species found to be most tolerant will be presented. Some of these plant species are already native to Kuwait and are adapted to local conditions, while others need to be acclimatized.

# 163 ORAL SESSION 42 (Abstr. 358–363)
## Small Fruit: Nutrition

358

GEL POLYMER CAN REDUCE LEACHING AND IMPROVE NUTRITION OF STRAWBERRY PLANTS

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

An experiment was performed using 'SuperSorb-C' polyacrylamide copolymer (gel) to determine whether the gel decreased leaching of nitrate, potassium, or phosphorus. The treatments were: gel polymer alone, gel polymer with fertilizer added, sand alone, sand with fertilizer added, gel polymer and sand, and fertilized gel with fertilized sand. One hundred ml of water was added to the pots every three days. This was done twelve times. Twenty-four hours after the water was added, the leach was removed from dishes beneath the pots. The leach was analyzed for nitrate, potassium, and phosphate content. Nutrient leaching was greater in sand than in gel or sand amended with gel. In other experiments, strawberry plants were grown in various combinations of sand, gel and fertilizer in 15 cm pots in the greenhouse. The plants were analyzed for nutrient content. Nitrogen and phosphorous content of plant tissue was increased when gel was mixed with the sand. Results of these experiments will be presented.

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EFFECTS OF NITROGEN FORM ON NITROGEN UPTAKE AND NITROGEN AND CARBON PARTITIONING IN 'CLIMAX' AND 'SHARPBLUE' BLUEBERRIES

Donald J. Merhaut* and Rebecca L. Darnell, Department of Horticultural Sciences, IFAS, University of FL, Gainesville, FL 32611.

Nitrogen uptake and N and C partitioning were evaluated in 'Climax' and 'Sharpblue' blueberries fertilized with different N forms. Plants were grown in silica sand and fertilized with a modified Hoagland's solution supplemented with 5 mmoles N as $NH_4$ or $NO_3$. After 12 months of growth, plants were dual labeled with 10% $^{15}N$-enriched-N as either $NaNO_3$ or $(NH_4)_2SO_4$ and $^{14}CO_2$ and harvested 12 hours after labeling. Total N uptake did not differ between N forms; however, partitioning differed. More N was partitioned to new shoots, leaves, and stems of $NH_4$ vs. $NO_3$ treated plants. N form did not affect current C partitioning in 'Sharpblue', but did affect C partitioning of 'Climax', with greater C partitioning to roots of $NO_3$ vs. $NH_4$ treated plants. The increased N partitioning to shoots in $NH_4$ vs. $NO_3$ treatments suggests that $NO_3$ reduction and/or translocation to shoots is limited. In 'Climax', greater C partitioning to roots and less N partitioning to shoots of $NO_3$ vs. $NH_4$ treatments may partially explain the decreased shoot growth observed in $NO_3$ treatments.

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MYCORRHIZAE IN HIGHBUSH BLUEBERRIES: SURVEY RESULTS AND FIELD RESPONSE TO NITROGEN

B. L. Goulart*[1], K.Demchak[1], M. L. Schroeder[1], and J.R. Clark[2]. [1]Department of Horticulture, The Pennsylvania State University, University Park, PA 16802; [2]University of Arkansas, Fruit Substation, Clarksville, Arkansas 72830

The current state of knowledge regarding the role of mycorrhizae in *Vaccinium* spp. will be summarized. Survey data from Pennsylvania, New Jersey and Michigan indicate higher levels of mycorrhizae in both native and commercial plantings than have been previously reported for other locations in the U.S. However, level of infection was not correlated with soil ammonium, nitrate or organic matter. In a separate experiment, nitrogen supplied either as urea (67 kg actual N/Ha) or in a slow release formulation suppressed mycorrhizal development. Mycorrhizae infection level was highest in the fine feeder roots close to the crown, as compared to medial or apical portions of the root.

361

SEASONAL NITROGEN ACCUMULATION BY MATURE 'CONCORD' GRAPEVINES

Eric J. Hanson* and G.S. Howell, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

Mature vigorous 'Concord' grapevines (Vitus labruscana, 'Bailey) at Clarksville, MI, were excavated at two to five week intervals from 29 April (bud break) until 28 September. Vines were separated into roots, wood (trunks and cordons), new shoots and leaves, and fruit. Tissues were weighed, then analyzed for total N to determine how much N vines accumulated annually, and when absorption occurred. Vines contained 18 g N at bud break, 75 g at fruit maturity, and 43 g when leaves were becoming senescent in late September. At fruit maturity when vine N content was highest, the new shoots and leaves, fruit, roots, and wood contained 53, 28, 11 and 8% of vine N, respectively. Vines absorbed N most rapidly between late May and early July, when the most rapid vegetative growth occurred.

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THE EFFECT OF PRUNING LEVEL, SOIL-APPLIED NITROGEN, AND FOLIAR NUTRIENT APPLICATIONS ON GROWTH, YIELD, AND FRUIT QUALITY OF 'CONCORD' GRAPEVINES

James S. Kamas*, R. M. Dunst, and R. M. Pool, Lake Erie Regional Center for Grape Research and Extension, 412 E. Main St., Fredonia, NY 14063

The effects of three levels of pruning severity, two rates of soil applied nitrogen, and a three spray regime of foliar nutrients were investigated at a commercial 'Concord' vineyard during the 1991 and 1992 growing seasons. While increased node number resulted in higher yields of less mature fruit, yield, vigor and fruit maturity

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were unaffected by rate of soil applied nitrogen. In both years, while yield was significantly reduced by the application of foliar nutrients growth and fruit maturity was unaffected.

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THE EFFECT OF SOME MICRONUTRIENTS ON THE YIELD AND FRUIT QUALITY OF WHITE BANATY SEEDLESS GRAPE VINES

Ahmed M. Akl, Abdul Mamed Wassel, Abdul Fattah Eid, and Massan M. Massan, Dept. of Horticulture, Faculty of Agriculture, Minia Univ., Ministry of Agric., Minia, Egypt

This experiment was carried out during the consecutive seasons of 1989 and 1990 at Minia Covernorate Egypt to study the effect of foliar application with Fe, Zn, Cu, and Mn (in sulphate form) each singularly and in all the possible combinations using three different concentrations (namely; 0.0, 300, and 600 ppm) on bud behavior and some vegetative and fruiting characteristics of White Banaty seedless grapevines. Under the conditions of the study, spraying White Banaty seedless grapevines with Fe, Zn, Cu, and Mn together each at 600 ppm is recommended to obtain the highest yield and retention of fruit quality.

# 164 ORAL SESSION 43 (Abstr. 364–370) Vegetable Crops: Culture and Management IV

364

SUSTAINABLE PRODUCTION SYSTEMS -- OVERSEEDING AND TILLAGE EFFECTS ON WEED SUPPRESSION AND BROCCOLI YIELD

Tammam Serage* and Ronald Morse, Department of Horticulture, Virginia Polytechnic Institute & State University, Blacksburg, Va. 24061-0327

Experiments were conducted at two sites in Virginia to study the effects of tillage (conventional plow-disk and no-tillage) and overseeding of legume cover crops (red clover, *Trifolium pretense L.*; white clover, *Trifolium repens* L.; and hairy vetch, *Vicia vellosa Roth.*) at transplanting on weed suppression and yield of 'Big Sur' broccoli (*Brassica oleracea var. Italica Plenck*). In both sites, weed suppression from overseeding was as good and in some cases superior to that in the herbicide-treated control plots. With the exception of hairy vetch in site 2, overseeding did not reduce broccoli yield. Weed suppression and broccoli yield were unaffected by tillage system and there were no tillage x overseeding effects. Based on our data, overseeding legumes could be an important component of our no-till system as we move towards more sustainable production methods for vegetables.

365

YIELD RESPONSE OF GREEN BEAN and TOMATO TO DIFFERENT TILLAGE AND COVER CROP SYSTEMS

Carolyn A. Prince*, Department of Horticulture, Iowa State University, Ames, IA 50011

Studies were conducted to evaluate conventional and reduced-tillage systems for winter annual cover crops used for early season weed suppression in green bean (*Phaseolus vulgaris* L.) and tomato (*Lycopersicon esculentum* Mill.) grown in central Iowa. The tillage systems and cover crops were: 1) conventional tillage annual rye, 2) no-till annual rye, 3) no-till hairy vetch, 4) no-till annual rye + hairy vetch mixture, and 5) conventional tillage in fallow plots. Experimental treatment plots were established as a randomized complete block design with four replications at the Horticulture Research Station near Ames. Early and total yield of green bean were affected by the tillage and cover crop systems. Differences were also observed in pod tenderness. Early tomato yield was influenced by the tillage and cover crop treatments but total yields were similar among all treatments. Soil organic matter and root dry weights were similar among all treatments for both crops.

366

EVALUATION OF VARIOUS GROWING MEDIA AND VARIETIES FOR THE PRODUCTION OF GREENHOUSE TOMATOES IN MISSISSIPPI

Richard G. Snyder*, Truck Crops Branch Experiment Station, Mississippi State University, P.O. Box 231, Crystal Springs, MS 39059.

Several growing media were tested with 2 varieties of greenhouse tomatoes to determine which media would be most appropriate for production of this crop in terms of yield and fruit quality, yet still economically feasible for small, family-based growers. Six 7.3 X 29.3 m greenhouses were used at the Truck Crops Branch Experiment Station in Crystal Springs, MS, with a randomized complete block design in each. The media included pine bark fines, rice hulls, rock wool, and coarse sand in five of the greenhouses, with the Dutch hybrid varieties 'Caruso' and 'Laura'. There were 3 replications of treatments, with 14 plants comprising one plot. In the sixth greenhouse, one variety at a time ('Caruso' or 'Laura') was used with 7 additional media, in 4 replications. These included 1) pine bark fines, 2) fines + 15% sand, 3) 90% fines + 10% chicken manure, 4) 90% fines + 10% peat, 5) 67% fines + 33% pine bark mulch + 4.75 kg lime $m^{-3}$ + 4.75 kg gypsum $m^{-3}$, 6) mulch, and 7) calcite clay. In most cases, yield of plants grown in pine bark fines or rice hulls was either superior to or not significantly different from those in rock wool. Those in sand and in calcite clay had significantly lower marketable and total yield and more culls than other treatments.

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INFLUENCE OF ORGANIC MULCHES AND DOUBLE CROPPING ON BELL PEPPER AND WINTER SQUASH YIELDS

Nancy E. Roe,* Herbert H. Bryan, and Peter J. Stoffella, Horticultural Sciences Department, IFAS, University of Florida, Gainesville, FL 32611

Dried sewage sludge (SS), municipal waste compost (MW), wood chips (WC), at 224 and 336 $t \cdot ha^{-1}$ and white polyethylene (WP) were applied as mulches on raised beds. 'Tivoli' squash was direct seeded. Squash yields were 13.4, 11.9, 7.7, and 5.1 $t \cdot ha^{-1}$ from WC, MW, WP, and SS treatments, respectively, with WC and MW having significantly higher yields than WP and SS. Fruit weight per plant was significantly higher in WP and WC plots. Pepper plants (cv. '32008') were transplanted into the same plots, 5 months after squash harvest. Pepper yields, 4.7, 4.2, 2.9, and 2.6 $t \cdot ha^{-1}$ on WP, MW, WC, and SS treatments, respectively, were not significantly different. Fruit weights per plant were significantly different and varied in the order WP>MW>WC=SS. No yield differences occurred between rates of organic mulches in either crop. Diseased plants in WP plots resulted in lower total yields than organic-mulched plots, but individual plants on polyethylene yielded higher than others.

368

LABOR-SAVING, HORIZONTAL SYSTEM FOR GREENHOUSE TOMATO PRODUCTION

James L. Green*, Horticulture Department ALS 4017, Oregon State University, Corvallis, OR 97331-7304

Four determinant tomato varieties were evaluated for salinity tolerance (0-4500 ppm added salinity), blossom-end rot susceptibility (0 or 50% ammonium nitrogen), and yield in the closed, insulated pallet system (CIPS). Growth and yield of the four tomato varieties in CIPS was greater than that of the controls in a surface-irrigated, open container production system.

Single-harvest, horizontal greenhouse tomato production in the CIPS, when compared with the conventional vertical system, has advantages: 1) Less labor is required with the determinant (non-trellised), parthenocarpic (nonpollinated), concentrated bloom-maturity, single-harvest tomato varieties. After transplanting into the CIPS, no additional water or fertilizer or handling are required during the production period. 2) Production per given production area is equal or greater. In CIPS plant density was four-times greater. 3) Supplementary lighting is more efficient.



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LETTUCE SEEDLING PRODUCTION FOR HYDROPONICS

Ramona A. Reiser* and Robert W. Langhans, Cornell University, Dept. of Floriculture & Ornamental Horticulture, 20 Plant Science Bldg., Ithaca, NY 14853

A production system for lettuce seedlings aimed at uniformity and repeatability for transplanting into a hydroponic system has been researched. Parameters for the initial 24 hr. germination period include low light levels (85 µmols), 20°C temperature to avoid thermodormancy, and no fertilizer in the media or nutrient solution to avoid imbibition and osmotic problems from salts. The 10 day nursery environment begins at 24 hrs. with 250 µmols of constant fluorescent light, 25°C and addition of 1/2 strength fertilizer. A sample size of 24 seedlings for dry weights at Day 7 and 11 (transplant) has established a growth curve for experimental comparison. Selection on Day 6 for uniformity at transplant eliminates small and large seedlings based on size and unfolding of first true leaf. Medias researched include oasis, rockwool, Metro Mix 360, peat-vermiculite and 'rubber dirt'. Container type, cell size and transplanting techniques have proven plastic cells with peat-vermiculite optimum. Fertilizer has been incorporated into the media or added at 0, 24, 48 or 72 hrs. after germination with 24 hrs. proving optimum. Dry weights and growth chamber uniformity were compared.

370

SENSITIVITY OF TOMATO AND BELL PEPPER TRANSPLANTS TO AN ORGANIC HERBICIDAL PRODUCT

Carolyn A. Prince* and Nick E. Christians, Department of Horticulture, Iowa State University, Ames, IA 50011

The purpose of this study was to determine the growth response of tomato (*Lycopersicon esculentum* Mill.) and bell pepper (*Capsicum annuum* L.) transplants to corn gluten meal, an organic by-product of the corn wet milling process with allelopathic and herbicidal properties. Replicated greenhouse studies were conducted to evaluate the effect of corn gluten meal applied at rates of 0, 2, 4, 6, 8, and 10 grams/plant to 5, 6, or 7 week old transplants. Shoot dry weight, root dry weight, and total leaf area decreased as the rate of corn gluten meal increased in the five week old tomato transplants. When the transplants were six or seven weeks old differences in shoot and root dry weights were similar for all treatment rates. Significant differences in shoot dry weight and leaf area of the 5, 6, or 7 week old bell pepper transplants were not observed. However, root dry weight of 5 week old bell pepper transplants decreased with increasing rates of corn gluten meal.

## 165 ORAL SESSION 44 (Abstr. 371–376) Floriculture: Culture and Management

371

DEVELOPMENTAL STUDIES OF ARTEMISIA ANNUA L.: FLOWERING AND ARTEMISININ PRODUCTION UNDER GREENHOUSE AND FIELD CONDITIONS

Jorge Ferreira*, Jules Janick, and James E. Simon, Purdue University, Center for New Crops and Plant Products, Horticulture Department, 1165 Horticulture Building, West Lafayette, IN 47907-1165

Cuttings of a clone of *Artemisia annua* L., grown under 16 h daylength for 55 days, were transferred to six photoperiod treatments in the greenhouse. Under short photoperiod (8, 10, or 12 h), plants flowered after two weeks; plants under long photoperiod (16, 20, or 24 h), remained vegetative until termination of the experiment in 10 weeks. When plants grown under long photoperiod treatments were transferred to 8 h photoperiod, flowering occurred two weeks later. Flower induction in plants grown under field conditions occurred when photoperiod was ca. 13.5 h. Artemisinin levels in all studies were found to be highest at anthesis. Artemisinin content was 4- to 11-fold higher in inflorescences than in leaves. Artemisinin declined after flowering but then increased towards seed maturity.

372

EFFECTS OF DAY AND NIGHT TEMPERATURE AND LIGHT LEVEL ON CATHARANTHUS ROSEUS

Grace M. Pietsch* and William H. Carlson, Michigan State University, 236 Plant Science Building, East Lansing, MI, 48824

The effects of 5 day temperatures (15-35 C), 5 night temperatures (15-35 C), and 3 light levels (50% shade, ambient, and supplemental light) were determined for Catharanthus roseus cv. 'Grape Cooler'. Average Daily Temperature (ADT) was calculated for the 25 day/night temperature combinations. As ADT increased, time to flower decreased with the shortest time to flower at an ADT of 32.5 C. Plants grown without supplemental light and with an ADT of 17.5 C or less did not flower at the termination of the experiment (110 days from seeding). Plants grown under higher ADT also had a higher leaf unfolding rate (LUR) than plants grown under the lower ADT. The increase in LUR was linear over the entire temperature range of 15-35 C. Application of supplemental lights increased shoot fresh weight and decreased time to flower.

373

QUALITY OF CUT FLOWER SNAPDRAGONS (*ANTIRRHINUM MAJUS* L.) AS INFLUENCED BY ROOT-ZONE HEAT AND NIGHT AIR TEMPERATURES.

Muhammad Maqbool* and Steven E. Newman, Department of Horticulture, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS 39762-5519.

Nine snapdragon cultivars of different response groups were transplanted into a double polyethylene greenhouse to determine the impact of no heat and 25C root-zone heat (RZH) and five night temperatures (NT) (10 to 26C at 4C increments) on plant growth and flower quality. Two weeks after transplanting, stem length was measured biweekly to compare growth rates under the existing conditions. Stems were tagged and the date recorded when the first floret showed color and harvested when the lower third of the florets were at anthesis. Flower quality was evaluated at harvest based upon stem length and fresh weight. Cultivars 'Oakland', 'Cheyenne', and 'Montezuma' were the first to bloom under 26C NT regardless of RZH; whereas, 'Potomac Pink' and 'Oklahoma' were delayed. Similar trends were observed under each NT with days to anthesis increasing with decreasing NT. Flower quality was improved at the lower night temperatures.

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DAY/NIGHT TEMPERATURE EFFECTS ON NEW GUINEA IMPATIENS MORPHOLOGY AND CARBON PARTITIONING.

John E. Erwin* and R.D. Heins, Department of Horticultural Science, University of Minnesota, St. Paul, Minnesota 55108; Department of Horticulture, Michigan State University, East Lansing, Michigan 48824.

*Impatiens hawkeri* Bull. cv 'Mimas' rooted cuttings were planted in 15.2 cm plastic pots and were placed in glasshouses maintained at 15, 20, 25, or 30C. Plants were rotated among glasshouses at 0800 and 1700hr each day (9 hr photoperiod) to yield 16 different day/night temperature (DT/NT) regimes. Data were collected on time of first flower, internode length, stem calibre, flower diameter, leaves per node, individual leaf area, and the dry weight of the leaves, stem, and flowers on a representative shoot from each plant. Morphology data were collected after 80 days. Plants grown at 15C required 27 more days to flower than plants grown at 30C. Internode length increased as the difference (DIF) between DT and NT (DT-NT) increased and as temperatures approached 25C. Stem calibre was unaffected by temperature. Flower diameter had an optimal temperature of 20C. Leaves per node and leaf area had optimal temperatures of 25C. Stem dry weight increased as DIF increased. Flower dry weight was greatest when plants were grown at constant 20C. Shoot and leaf dry weight were greatest in the 25 DT/15C NT regime.

375

DAY/NIGHT TEMPERATURE EFFECTS ON *PELARGONIUM ZONALE* L. FLOWER DEVELOPMENT AND LEAF UNFOLDING RATE.

John E. Erwin and Debra J. Schwarze*, Department of Horticultural Science, University of Minnesota, St. Paul, Minnesota, 55108.

Rooted cuttings of *Pelargonium zonale* cv 'Fantasy' were planted in 12.7 cm pots and were placed in glasshouses maintained at 12, 18, 24 or 30 ± 2C. Plants were rotated among glasshouses at 0800 and 1700hr each day (9 hr photoperiod) to yield 16 day/night temperature (DT/NT) treatments. Data



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were collected on primary stem node number after 60 days. Total flower number per inflorescence, flower diameter, peduncle length and inflorescence, peduncle and flower dry weight were collected when all flowers were visible on an inflorescence. Flower number per inflorescence increased exponentially from 23 to 52 flowers/inflorescence as the average daily temperature (ADT) decreased from 30 to 12C. Inflorescence and peduncle dry weight decreased exponentially from 1.05 to 0.28g and 0.34 to 0.05g, respectively, as ADT increased from 12 to 30C. Flower dry weight and diameter were not affected by temperature treatments. Peduncle length increased from 9.2 to 17.1cm as the difference between DT and NT (DT-NT) increased from -12 to +12C. Node unfolding rate increased as temperature increased from 12 to 24 then decreased as temperature increased to 30C.

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INTERACTION BETWEEN PHOTOPERIOD, TEMPERATURE FLUCTUATIONS AND CYTOKININ ON *PHARBITIS* FLORAL INDUCTION.
Cheryl L. Reese* and John E. Erwin, Department of Horticultural Science, University of Minnesota, St. Paul, Minnesota, 55108.

Etiolated seedlings of *Pharbitis nil* Chois. cv 'Violet' were germinated and grown at 24C for 4 days and were then placed in controlled environment chambers (CEC) maintained at 12, 18, 24, 30 or 36C for flower induction. Seedlings were rotated among chambers to result in 25 day/night temperature (DT/NT) treatments. Photoperiod was 8, 12, or 16 hr (250 $\mu$mol $s^{-1}$ $m^{-2}$). N-6-benzyladenine (BA) (120 $\mu$M) was applied to half the seedlings in each treatment 1hr prior to the inductive night period. After the inductive night period, seedlings were placed in a CEC maintained at 24C under continuous light. Data were collected on percent flowering and flower number at anthesis. Flowering was a function of NT and photoperiod. Flowering increased as night length increased and as NT approached 30C. DT (30C) promoted flowering to a lesser extent than NT. Flowering did not occur on plants grown with a 8hr night length. Flowering occurred on plants grown with a 12hr night length when BA was applied and when plants were grown at 30/24 or 30/30C DT/NT. Seedlings flowered under the 16hr night length when NT was 30C without BA application; flowering occurred with 24 or 30C NT when BA was applied.

## 174 COLLOQUIUM 3 (Abstr. 377–382) International and National Opportunities for Horticultural Consultants

377
HORTICULTURAL CONSULTING--A NATIONAL AND INTERNATIONAL PERSPECTIVE
L. Gene Albrigo, Citrus Research and Education Center, University of Florida, IFAS, 700 Experiment Station Road, Lake Alfred, FL 33850

There is a wide spectrum of consulting opportunities available for many horticulturists who wish to pursue them. These range from full-time career consulting to the part-time endeavor typical for many academics and retirees. Consultants are employed by individual producers, commodity groups, governments, international agencies or university groups (as in departmental review processes and international programs). These activities will be discussed primarily in relation to academic responsibilities along with guidelines, procedures and policies one typically encounters when undertaking consulting.

378
CONSULTANT'S CONTRIBUTION TO HORTICULTURAL PROJECTS IN DEVELOPING COUNTRIES
Hamdy M. Eisa* and Douglas A. Forno, Agriculture Technology and Services Division, World Bank, 1818 H Street, NW, Washington, DC 20433

In addition to their nutritional benefits, horticultural crops contribute significantly to the development process by providing value added activities, intensive labor use, increasing farmers' income and generation of foreign exchange through exports. In addition to economic benefits, the World Bank's policies emphasize sustainable development and poverty alleviation as primary objectives in the development process. To correctly identify market opportunities and economically viable production practices, development agencies rely heavily on consultants' appraisal of investment opportunities. Successful identification of markets particularly for exports is the primary lever to tap the countries' production potential. Therefore, consultants engaged by development agencies should have a holistic view of the total development picture of horticultural commodities under consideration and up-to-date information of market niches, agreements and prospects for fresh and processed forms. Selection criteria and guidelines for the use of individual consultants and consulting firms have been prepared by the World Bank.

379
THE FOOD AND AGRICULTURE ORGANIZATION--UN: HORTICULTURAL-RELATED ACTIVITIES AND CONSULTANT RECRUITMENT
Alison Hodder*, Hort. Crops Group, Food and Agriculture Organization--UN, Via delle Terme di Caracalla, Rome, Italy

FAO's function is to assist national governments with agricultural institutional strengthening, food and agricultural development projects, and gathering and dissemination of commodity production and marketing information. Horticultural concerns include activities for genetics resources, production and postharvest handling. Separate divisions administer each of these subject areas. In the past, most of the funding support for these activities has been from the United Nations Development Programme. Currently funding support is more diversified but also more limited. FAO approaches to consultant recruiting and qualifications for horticultural consultants will be discussed.

380
HORTICULTURAL PROGRAMS OF USAID--CONTRACTS AND CONSULTANTS
Harvey J. Hortik, Bureau for Science and Technology, Agency for International Development, Washington, DC 20523

The United States has maintained a strong commitment to international development in agriculture, including horticulture, through various programs directed primarily by USAID. The development and execution of many of the programs are contracted to private US companies and universities. These contractors hire consultants, using some guidelines from AID. Situations where USAID hires consultants directly and the criteria used will be discussed also.

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HORTICULTURAL CONSULTING FOR CHEMONICS--A PRIVATE TECHNICAL SERVICES AND PROJECT MANAGEMENT COMPANY
John E. Lamb, Chemonics International, 5805 Blue Lagoon Drive, Suite 170, Miami, FL 33126

Chemonics has consulting experience with private enterprises, investment and trade promotion entities, research centers, universities, foreign assistance donors, and government and parastatal institutions in over 60 countries. A majority of this activity is financed by AID. Horticultural activities have emphasized all aspects of work with edible crops but consulting assignments have included cut flowers, ornamental plants, foliage, spice and nut crops. In recruiting long-term and short-term consultants, Chemonics considers quality and relevance of formal education, work experience, analytical and interpersonal skills, familiarity with applicable cultures and languages and demonstration of successful performance in appropriate activities.



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INTERACTIONS OF UNIVERSITY INTERNATIONAL PROGRAM OFFICES WITH FUNDING AGENCIES; HOW HORTICULTURISTS CAN BECOME INVOLVED

L. George Wilson, International Programs, North Carolina State University, Box 7645, Raleigh, NC 27695-7645

The role of university international programs offices in facilitating involvement of horticulturists in international and national consulting opportunities will be discussed. Horticulturists and other faculty are frequently included in the implementation of contracts and subcontracts managed by universities, university consortia and public and private sector agencies. International programs offices serve as brokers by maintaining contact with faculty interested in consulting assignments and with a diversity of organizations who require consulting expertise. Experience is important to those seeking consultants' services. Therefore, it is recommended that those faculty wishing to get established in international and national consulting activities remain flexible and perhaps initially accept broader based assignments. Faculty should determine in advance the position of their university administration regarding consulting.

## 175 ORAL SESSION 45 (Abstr. 383–390) Fruits/Nuts: Nutrition

383
DIFFERENCES IN N PARTITIONING BETWEEN STANDARD AND SPUR-TYPE APPLE TREES

Timothy Righetti*, H. Khemira, and A.N. Azarenko, Department of Horticulture, Oregon State University, Corvallis, OR 97331-7304.

Young bearing spur and standard type apple trees were given either 60 or 120 g actual N as ammonium nitrate depleted in $^{15}N$ (0.01 atom percentage $^{15}N$) in Mar. 1992. The fertilizer was soil applied to 3 single replicate trees for each dose and each tree-type. Spur leaves had similar N contents for both types and both doses. The difference between the two types appeared to be related to differences in the relative number of spur leaves rather in their behavior. The percentage of N from the fertilizer in leaves from spur-type trees was 36% higher than those from standard type trees at low N rates, but 72% higher at high N rates. Doubling the N rate did not increase fruit N concentration in standard trees, but it did increase it in spur-type trees. The latter appeared to be more responsive to N management practices and more susceptible to deleterious effects on fruit quality of high N applications.

384
IRON HUMATE AS A SOURCE OF IRON FOR CITRUS IN HIGH-pH SOILS

Ashok K. Alva*, University of Florida, IFAS, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, FL 33850

Availability of iron (Fe) to plants is dependent on the stability of chelate to bind Fe. In soils with pH greater than 7.5, only EDDHA (Ethylenediamine di-o-hydroxyphenyl acetic acid) is the stable chelate to complex Fe. However, Fe EDDHA is an expensive material. Iron humate (IH) is a by-product of drinking water treatment, wherein, Fe is complexed with humic and fulvic fractions of the river water. Field experiments using Hamlin orange and Flame grapefruit on Swingle citrumelo rootstock conducted in two locations with high pH soils (> 7.5) have shown a significant increase in leaf Fe concentrations when IH was applied to the soil. Since the solubility of Fe from IH is lower than that of Fe EDDHA, the long-term effects of IH on growth and mineral nutrition of citrus are under investigation.

385
CRITICAL ZINC$^{+2}$ ACTIVITIES FOR SOUR ORANGE SEEDLINGS DETERMINED USING A CHELATOR-BUFFERED NUTRIENT SOLUTION

Dariusz Swietlik* and Linsen Zhang, Texas A&I University Citrus Center, P.O.Box 1150, Weslaco, TX 78599

Chelator-buffered nutrient solutions were used to study the effect of different levels of $Zn^{+2}$ activity on the growth of various tissues of sour orange seedlings. $Zn^{+2}$ activities were calculated with a computerized chemical equilibrium model, GEOCHEM-PC, and were buffered by adding 74 and 44 uM of diethylenetriamine pentaacetate (DTPA) in excess of the sum of Fe, Mn, Zn, and Cu in Exp. 1 and 2, respectively. Root dry wt. was least sensitive to Zn deficiency followed by leaf number and white root growth, stem dry wt., leaf dry wt., shoot elongation and leaf area. The critical $Zn^{+2}$ activities in the nutrient solutions for these growth parameters ranged from $10^{-10.4}$ to $10^{-10.05}$M. Increases in growth were observed from Zn applications even when visible Zn deficiency symptoms were absent. Seedlings with > 23 ppm Zn in their leaves did not respond to further additions of Zn to the nutrient solution. Zinc foliar sprays were less effective than Zn applications to the roots in alleviating severe Zn deficiency.

386
RECLAIMED WATER AND IRRIGATION OF MATURE 'REDBLUSH' GRAPEFRUIT TREES.

M.A. Maurer* and F.S. Davies, University of Florida, Horticultural Sciences Dept., PO Box 110692, Gainesville, FL 32611.

A field study was conducted near Vero Beach, Fla. on poorly drained (flatwoods) soil to determine the effects of reclaimed water on the growth and development of mature 'Redblush' grapefruit trees (*Citrus paradisi* Macf.) on sour orange (*Citrus aurantium* L.) rootstock. Treatments consisted of a control (canal water), and reclaimed water applied at 2.31, 3.07 and 3.86 cm/wk. For the first two years after treatments were implemented there were no significant differences among treatments in yields, trunk diameter, fruit growth rates or fruit quality (fruit and juice weight, total soluble solids, acids or solids:acid ratio), and leaf nutrient levels. Moreover, although reclaimed water increased leaf B, Na and Cl levels over control values, no toxicity symptoms were observed. Soil moisture content was always well above field capacity for the reclaimed water treatments; however, soil redox potentials rarely were in the anaerobic range. The reclaimed water treatment receiving 3.86 cm/wk also provided about 80 kg/ha of N which is ⅔ of the yearly N requirement. All reclaimed water treatments caused significantly greater weed growth than control treatments.

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CROP DEMAND INCREASES POTASSIUM UPTAKE BY MATURE PRUNE TREES

S.A. Weinbaum,* F.J.A. Niederholzer, S. Ponchner, R.C. Rosecrance, R.M. Carlson, A.C. Whittlesey, and T.T. Muraoka, Department of Pomology, University of California, Davis, CA 95616-8683 USA

Two heavily-cropping, twelve-year-old prune trees (Prunus domestica L., syn. 'Prune d'Agen') were compared with two adjacent trees which were defruited during stage II of fruit growth (28 May). Trees were uprooted, dissected, and processed to determine total nonstructural carbohydrates, tree nutrient contents and within-tree distribution at the time of fruit maturity (28 July). Trees defruited 2 months earlier contained 5 times as much starch and 2.5 times as much total nonstructural carbohydrates (TNC) in leaves and perennial tree parts as did cropping trees at the time of fruit maturity.

Cropping trees absorbed about 90 g more K during stage III of fruit growth than did defruited trees during the same interval (28 May - 28 July). Vegetative trees parts (i.e., trunk, branches, roots, and leaves) in cropping trees generally had lower K contents than did defruited trees at the time of fruit maturity. Fruit demand for K was associated with increased K uptake from the soil despite reduced levels of TNC in the roots and the probability of reduced root growth. Potassium uptake by heavily cropping trees was not resource limited when K was supplied regularly through the drip irrigation system.



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THRESHOLD LEAF LEVELS OF ZINC INFLUENCING NUT YIELD AND VEGETATIVE GROWTH IN PECAN
Darrell Sparks, Department of Horticulture, University of Georgia, Athens, GA 30602-7273

The modified Mitscherlich plant growth model was used to quantify the threshold leaf level of Zn influencing nut yield and vegetative growth on an orchard basis for pecan [*Carya illinoensis* (Wangenh.) C. Koch]. Four indexes of tree performance including number of trees without deficiency symptoms, vegetative growth, nut yield, and trees without leaf deficiency symptoms plus yield were analyzed with regard to the concentration of Zn in the leaf. Data available from both published and unpublished sources on any single performance index were combined for mathematical modeling. The threshold value for leaf Zn was determined to be ≈40 $\mu g \cdot g^{-1}$ for these tree performance indexes. Thus, nut yield and vegetative growth in an orchard will be reduced with a leaf Zn concentration below ≈40 $\mu g \cdot g^{-1}$, but will be unaffected above this value.

389
PARTITIONING AND RECOVERY OF FOLIAR AND SOIL NITROGEN IN 'COMICE' PEAR
Habib Khemira*, T.L. Righetti, D. Sugar, and A.N. Azarenko, Dept. of Horticulture, Oregon State University, Corvallis, OR 97331-7304

Mature 'Comice' pear trees were given 4 l of a 5% urea solution enriched in $^{15}N$ ( 0.6 atom percentage $^{15}N$) either as a soil application (S), a foliar application with the ground covered to prevent soil contamination (F), or as a foliar application with the ground uncovered (F+S). The treatments were applied in mid-October 1990 to 6 single replicate trees each. The following spring, flower buds from trees that received either F or F+S had 38% of their N from the applied fertilizer. Trees from the S treatment had no label in their buds. In 1991, half of the trees were removed and their components analyzed for total and isotopical N to estimate N recovery. The relative enrichment of different tree parts in $^{15}N$ was similar for the three modes of application. This suggests that unlike fall foliar applied N, reserve N is more uniformly distributed within the tree. N recovery depended more on tree biomass ($r^2$ = 0.89, $P$ = 0.001) than on the mode of fertilizer application. There was also a positive correlation between tree vigor and fruit N content.

390
NATURAL RECYCLING OF NUTRIENTS vs. CHEMICAL FERTILIZERS ON SHADED COCOA PLANTATIONS
Victor H. Delgado-Nuñez, and J. Angel Saavedra[1]* CE Huimanguillo, INIFAP Apdo. postal 19, Huimanguillo, Tab. 86400 [1]CE Cotaxtla, INIFAP Apdo. postal 429, Veracruz, Ver. 91700, México

Eight-year-old cocoa trees growing under shade of different tree species were treated during three years with foliar and soil fertilizers and compared to non fertilized trees. We hypothesize that non fertilized trees under shade condition recycle their own nutrients by using fallen foliage from the shade trees and, in a fertile soil, they do not need addition of chemical fertilizers. Eight treatments, selected from growers' technology were evaluated under a randomized complete block design with 4 replications and 12 trees per experimental unit. Fertilized treatments did not differ from the non fertilized treatment in dry bean production and tree growth. This indicates that shaded cocoa plantations established in good fertile soils sustain their own nutrient requirements. The results also showed that foliar urea (1%) reduced cherelle wilt (yellowing and subsequent shriveling of young fruits).

# 176 ORAL SESSION 46 (Abstr. 391–397)
# Vegetable Crops: Breeding and Genetics

391
INHERITANCE OF BACTERIAL CANKER RESISTANCE IN THE TOMATO LINE HAWAII 7998
William H. McCarthy*, Randolph G. Gardner,Department of Horticultural Science,North Carolina State University,2016 Fanning Bridge Rd. Fletcher, NC 28732

*Clavibacter michiganensis* subsp. *michiganensis* (Smith) Davis et al. incites bacterial canker of tomato and is a significant disease in many tomato growing areas of the world. In previous studies, the accession Hawaii 7998 displayed a high degree of resistance to bacterial canker in North Carolina. Hawaii 7998 and the bacterial-canker-susceptible breeding line NC EBR-3 were crossed to develop reciprocal $F_1$, $F_2$ and BC populations for genetic analysis of bacterial canker resistance. Plants were evaluated for resistance in field and greenhouse studies. The field study indicated no maternal effect. Generation means and variance analysis indicated that foliar resistance was moderate and quantitative. Narrow sense heritability ($h^2$) was estimated as 0.24. By regressing $F_3$ progeny means onto $F_2$ plant values, $h^2$ for foliar resistance was calculated as 0.35. When data for both $F_2$ and $F_3$ generations were transformed into standard units, $h^2$ was 0.44. In greenhouse studies generation means and variance indicated wilt resistance to be quantitative in nature, but $h^2$ was estimated as low (0.09). The $F_1$ generation mean was similar to the resistant parent.

392
GENETIC MAPPING AND QTL ANALYSIS OF A RECOMBINANT INBRED TOMATO POPULATION USING MOLECULAR MARKERS
I. Paran, D. Zamir, and J.L. Goldman* Department of Field and Vegetable Crops, The Hebrew University of Jerusalem, Rehovot, Israel, and *Department of Horticulture, University of Wisconsin, 1575 Linden Drive, Madison, WI, 53706, USA

Recombinant inbred (RI) populations are a valuable genetic resource for mapping traits. An RI population composed of 100 F8 lines was developed from a cross of the cultivated tomato and a related wild species *L. cheesmanii*. RI lines were grown in field trials in 1991 and 1992, and were evaluated for soluble solids, fruit weight, pH, and other parameters. Lines were genotyped for 130 RFLP and RAPD markers. A genetic map of the RI population was constructed, revealing large increases in recombination frequency between linked markers (as compared to F2 data) which is characteristic of RI populations. Percent heterozygosity was greater than expected for F8 lines. Segregation at most marker loci was skewed toward *esculentum* alleles. Quantitative trait locus (QTL) analysis revealed significant associations between selected marker loci and each of the traits measured, many of which were consistent with associations observed in this cross in the F2, thus confirming the chromosomal location of important QTL in processing tomato.

393
RECOMBINATION OF TOMATO FUSARIUM WILT-RESISTANCE GENES
J.W. Scott*[1], John Paul Jones[1], S.H. Brommonschenkel[2]and S.D. Tanksley[2], [1]Gulf Coast Research and Education Center, IFAS, University of Florida, 5007 60th St. E., Bradenton, FL 34203; [2]Dept. of Plant Breeding, 252 Emerson Hall, Cornell University, Ithaca, NY 14853

Tomato (Lycopersicon esculentum) line E427 contains Fusarium wilt resistant gene I-3 on chromosome 7 and I-2 (and presumably the linked I) genes on chromosome 11. E427 was crossed with 'Bonny Best' (i, i-2, i-3) and backcrosses (BC) to 'Bonny Best' and $F_2$ seed were obtained. Self pollination of 187 BC and 150 $F_2$ plants were made. Progeny were screened against Fusarium races 1, 2, and 3 and lines with recombinant ratios were self-pollinated and rescreened until homozygous. Five lines were resistant to races 2 and 3 but susceptible to race 1. These had the isozyme band got-2 linked to I-3, RFLP markers linked to I-3 and no RFLP markers linked to I-2. Five lines were resistant to race 1 but susceptible to races 2 and 3. These had the susceptible got-2 band and no RFLP markers linked to I-3 or I-2. $F_2$ complementation tests of 2 of these lines with 'Manapal' (I) indicated they contained I. Three lines were resistant to race 2 but susceptible to races 1 and 3. These had the susceptible got-2 band, I-2 linked RFLP markers, and no I-3 linked RFLP markers.



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GENES FROM *LYCOPERSICUM CHMIELEWSKII* THAT AFFECT TOMATO SOLUBLE SOLIDS, pH, AND YIELD.

F. Azanza*, J.A. Juvik, Department of Horticulture, University of Illinois, Urbana, IL 61801, and S.D. Tanksley, Department of Plant Breeding and Biometry, Cornell University, NY 14853.

Two chromosomal segments from the wild tomato *L. chmielewskii* have been introgressed into the *L. esculentum* genome. Using molecular markers they have been mapped to the middle and terminal regions of chromosome 7 (7M and 7T, respectively). This study was conducted to further clarify the physiological influence of the introgressed segments on tomato soluble solids, and other fruit and yield parameters. Sixty-four BC2F5 recombinant inbreds were developed from a cross using LA1501 (*L. esculentum* line that contains both fragments from *L. chmielewskii*) as the donor parent, and VF145B (processing cultivar) as the recurrent parent. Recombinant inbreds were classified in four groups (++: inbreds without either of the fragments, 7M+: with only the 7M fragment, +7T: with only the 7T fragment and, 7M7T: with both fragments) based on RFLP information, and then compared to each other for all the parameters under study. Inbreds homozygous for the 7M fragment displayed greater soluble solids (26%) and higher pH (0.10) than the control group (++), through a physiological mechanism related to water uptake. The 7L fragment did not influence either soluble solids or pH, but was observed to significantly increase fruit yield by 11%. A gene or genes that increase yield without affecting soluble solids or pH may have potential in the development of commercial cultivars.

395

INHERITANCE OF TOMATO FRUIT CAROTENOID CONTENT IN POPULATIONS DERIVED FROM A CROSS OF *LYCOPERSICON ESCULENTUM* x *L. CHEESMANII*

John R. Stommel, USDA-ARS, Vegetable Laboratory, Beltsville, MD 20705-2350

Tomato fruit carotenoid content was measured in mature fruit of parental, $F_1$, $F_2$ and backcross populations derived from an initial cross of *L. esculentum*, cv. Floradade, with the orange fruited *L. cheesmanii*, LA 317. Segregation patterns for orange flesh color and percent $\beta$-carotene in $F_1$, $F_2$ and backcross populations fit expected models for a single dominant gene conditioning a high percentage $\beta$-carotene content and resultant orange fruit pigmentation. The inheritance of $\beta$-carotene in *L. cheesmanii* paralleled that of the *B* gene described in *L. hirsutum*. $\beta$-carotene was generally accumulated at the expense of lycopene in orange-fleshed individuals. Correlations between carotenoid type and total carotenoid content were not evident. Variation observed in segregating $F_2$ and backcross populations for total carotenoid content suggested that gains in selection for increased $\beta$-carotene and lycopene content may be realized.

396

BREEDING TOMATOES RESISTANT TO TOMATO YELLOW LEAF CURL VIRUS.

M. A. Kasrawi* and A. Mansour, Departments of Plant Production and Protection, respectively, Faculty of Agriculture, University of Jordan, Amman, Jordan.

Over a 2-year period, disease incidence and severity caused by tomato-yellow-leaf-curl-virus (TYLCV) in lines of tomato (Lycopersicon esculentum) derived from interspecific hybridization with wild species of L. pimpinellifolium, L. hirsutum and L. peruvianum ranged from non to intermediate. The average fruit weight of these lines ranged from 25 to 90 grams. Crosses between TYLCV-resistant lines derived from the same wild species produced progenies similar to their parents in the level of resistance. However, progenies of 2-wild species combination showed little higher in levels of resistance than their parents. Analysis of F1, F2 and backcross populations from crosses of the most promising TYLCV-resistant lines with the susceptible cultivar showed that resistance appeared to be incomplete dominant and controlled by few genes.

397

GENETICS OF RESISTANCE TO DOWNY MILDEW IN CUCUMBERS. Mohamed A. Abo Bakr, Seif H. Gad El-Hak* and H.M. Yacoub. Dept. of Hort., Fac. of Agric., Minia Univ. and Sids Res. Station, Ministry of Agric., Beni Suef, Egypt

A study was conducted to determine the inheritance of resistance to downy mildew caused by Pseudoperonospora cubensis in the cucumber genotypes;cv. Beit Alpha, line 1902 M and line TMG-1. The common cultivated cultivar in Egypt Beit Alpha was found to be highly susceptible to downy mildew infection. Two crosses were made as follows: 1- "line 1902 M"X"Beit Alpha" 2-"line TMG-1" X"Beit Alpha". The resulting $F_1$, $F_2$ and backcross generations of the first cross and $F_1$ and $F_2$ populations of the second cross were observed for downy mildew reactions in the field under natural infestiation conditions. Susceptibility of the $F_1$ populations to downy mildew was completely dominant in both crosses. Segregation ratios of the $F_2$ and backcrose populations of the cross "line 1902 M X Beit Alpha" indicated that two pairs of recessive genes controlled the tolerance reaction of Line 1902 to the fungus. Segregation ratio for reaction to downy mildew in the $F_2$ population of cross "line TMG-1 X Beit Alpha" indicated that three pairs of recessive genes were controlled the resistance reaction to the fungus. The following tentative genotypes for downy mildew reactions are proposed: Cv. Beit Alpha: $Dm_1Dm_1Dm_2Dm_2Dm_3Dm_3$ (Suscceptible), Line 1902 M: $dm_1dm_1dm_2dm_2Dm_3Dm_3$ (Tolerant) and Line TMG-1 $dm_1dm_1dm_2dm_2dm_3dm_3$ (Resistant).

## 177 ORAL SESSION 47 (Abstr. 398–405)
## Vegetable Crops: Nutrition

398

OPTIMIZING NITROGEN EFFICIENCY IN DRIP-IRRIGATED VEGETABLE PRODUCTION.

T.K. Hartz, Department of Vegetable Crops, University of California, Davis, CA 95616; and R.F. Smith and K.F. Schulbach, University of California Cooperative Extension.

Drip irrigation, by removing nitrogen application from other cultural restraints, allows efficient N management. In intensive work with commercial vegetable operations in California's central coastal valleys, we have formulated a nitrogen management plan for drip-irrigated vegetable production. The main elements of the plan are: a) estimation of net N mineralization potential of a field, b) suction lysimetry to monitor early-season soil N availability, c) weekly tissue sampling for conventional laboratory analysis or on-farm 'quick test' analysis of petiole sap, and d) irrigation scheduling based on valid evapotranspiration estimates. Net N mineralization estimates can be made from in-situ incubations, soil test information, and/or previous cropping history. Suction lysimetry provides a mechanism to delay or minimize early-season N applications. The development of on-farm technology for $NO_3$-N analysis of petiole sap has broadened the acceptance of routine tissue testing.

399

DIURNAL CHANGES IN NITRATE CONCENTRATION IN POTATO LEAVES

Steven E. McLaskey*, Peter Minotti, and Don Halseth, Department of Fruit and Vegetable Science, Plant Science Building, Cornell University, Ithaca, NY 14853

The purpose of this project was to determine what, if any, are the diurnal changes in nitrate concentration in potato leaves. In dried petioles there was a decrease in nitrate, on most days, from early morning to the middle of the day. The pattern of the change was found to be influenced to some extent by weather conditions, and some differences in average nitrate levels were found on different days. Nitrate in fresh sap was measured with a nitrate specific ion electrode and two quick tests. Nitrate in fresh petiole sap was found to have a different diurnal pattern than nitrate in dried petioles. That is, there was usually an increase in nitrate-N from early morning to the middle of the day, although the change was sometimes not significant. The nitrate concentration of the fresh sap was found to be sensitive to the water status of the plants and decreased after a heavy rain. In most cases the difference in nitrate concentration between plots receiving 83 kg N/ha and plots receiving 165 kg N/ha was greater than the diurnal change.

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NITROGEN CONCENTRATIONS TO MAXIMIZE YIELD AND DECREASE LEACHATE-N IN PEPPERS GROWN IN ROCKWOOL.

M.K. Schon*, M.S. Compton, I. Burns and E. Bell, The Land, EPCOT Center, Lake Buena Vista, FL 32830

Many nutrient recommendations for greenhouse production of vegetable crops were developed in northern climates and may not be optimum for Florida production. Experiments were designed to determine nitrogen (N) levels that would maximize yield of rockwool-grown peppers (Capsicum annuum 'Midal') in Florida, while reducing nitrate leaching. Treatment 1 plants were fed 60, 90, and 120 ppm N during vegetative, early fruit, and late fruit stages, respectively. Plants in Treatments 2 and 3 were grown at 120 and 175 ppm N, respectively, throughout their entire growth cycle.

In Trial 1, increasing N did not affect the number of marketable fruit produced, but increased fruit size. Marketable fruit weight was significantly greater for plants in Treatment 3 compared to Treatment 1. However, there was not a significant difference in marketable yield between plants grown at 120 ppm N and 175 ppm N. Excess N provided by the 175 ppm N treatment caused a 10% increase in total water use and a 250% increase in nitrate-N in the leachate compared to the 120 ppm N treatment. Nitrogen level did not affect blossom end rot (BER) occurrence. Early results of Trial 2 indicate higher occurrence of BER with increasing N concentration and are again showing that 120 ppm N will maximize yield and reduce environmental impact of greenhouse pepper production in Florida.

401

FOLIAR NUTRITION OF TOMATOES UNDER SUSTAINABLE SYSTEMS USING PLANT MULCHES AND LOW-N INPUT

R. F. Korcak*, A. Abdul-Baki, and J. Teasdale, US Department of Agriculture, Agricultural Research Service, Fruit Lab., Veg. Lab. and Weed Sci. Lab., respectively, BARC-W, Beltsville, MD 20705-2350

Tomato (Lycopersicon esculentum Mill., cv. Sunny) plants were grown in a sustainable agricultural system of mulches: black plastic, paper, hairy vetch, crimson clover, and hairy vetch + rye. Total yields were highest with hairy vetch (85.8 t $ha^{-1}$) and lowest with paper mulch (30.0 t $ha^{-1}$). The low fertilizer input hairy vetch, crimson clover and hairy vetch + rye treatments received one-half the N-P-K fertigation that was applied to other treatments. Immediately before mowing the cover crops, samples were analyzed. Five weeks after transplanting the tomatoes and at the end of 12 weeks, leaf samples were analyzed for macro- and micro-nutrients. Results of the cover crop analyses indicated minimal differences in N, P, K, Ca, Mg, Mn, B, and Fe concentrations. Tomato leaf analyses at 5 weeks after field planting showed that, among the macro-nutrients, only K was significantly higher in the hairy vetch, hairy vetch + rye, crimson clover, and black plastic treatments than in bare soil and paper mulch. End-of-season leaf analyses showed that significantly higher K was found in the vetch + rye treatment compared to all other treatments.

402

NITROGEN FERTILITY, HARVEST FREQUENCY AND WEED DENSITY EFFECT THE PRODUCTIVITY OF A COLLARD : COWPEA INTERCROP.

Francis M. Itulya, Department of Horticulture, Egerton University, Njoro, Kenya and John B. Masiunas*, Department of Horticulture, University of Illinois, Urbana, IL 61801.

A study was conducted at the Irrigated Vegetable Crops Research Farm in Champaign, IL to determine the effects of nitrogen levels, collard harvesting frequency and density of redroot pigweed (*Amaranthus retroflexus* L.) infestation on the productivity of a collard : cowpea intercrop. The experiment was a split block design with 3 replications. The nitrogen was applied in the form of urea at 0, 80, 160, and 240 kg N $ha^{-1}$. Redroot pigweed was seeded at 0, 300, and 1200 seeds $m^2$. The more frequently collard was harvested the greater its competitiveness. Intercropping collard and cowpea reduced the growth of redroot pigweed. Nitrogen favored growth of the collard : cowpea intercrop and did not effect redroot pigweed growth.

403

FIELD CHLOROPHYLL AND PETIOLE SAP NITRATE INDICATE THE NITROGEN STATUS OF POTATO VARIETIES

Peter L. Minotti* and Donald E. Halseth
Department of Fruit and Vegetable Science, Cornell University, Ithaca, NY 14853

We report field experiments, under N limiting conditions, where applied N was varied between 0 and 252 Kg/ha. Two varieties (Castile and Allegheny) were planted in 1990 and 3 varieties (Katahdin, Monona and Superior) were planted in 1991. A curvilinear tuber yield response to N rate was obtained both years for all varieties with maximum yields at about 168 Kg/ha of N. Weekly field measurements with a hand-held chlorophyll meter (Minolta SPAD 502) were highly correlated to yield, to fresh petiole sap nitrate, to dry petiole nitrate and to the total N of whole leaves, all of which were generally highly correlated to each other and markedly affected by applied N. As plants matured the chlorophyll readings, and concentrations of nitrate and N decreased. In general variety differences or variety x N rate interactions were not significant which encourages the use of such tests to avoid unnecessary N sidedressings.

404

GREEN CAULIFLOWER (BROCCOFLOWER®), BRASSICA OLERACEA L., BOTRYTIS GROUP, CV. ALVERDA, RESPONSE TO N AND K RATES AND PLANT SPACING ON SAND

Alexander A. Csizinszky, Univ. of Fla., IFAS, Gulf Coast Research and Education Center, Bradenton, FL 34203

Green cauliflower, cv. Alverda, was raised on light sand during the winter-spring (Jan.-Apr.) 1992. Experimental design was a split-plot. Main plots were 4 N rates: 0,49,98 and 196 N kg $ha^{-1}$; sub-plots were the same K rates, and sub-sub plots were two within-row spacings: 23.0 and 30.5 cm. Seedlings were transplanted in double rows on the polyethylene mulched bed at 30.5 cm between row spacing. Treatments were arranged in a randomized complete block, replicated four times. Nitrogen source was $NH_4NO_3$ and K sources were KCl and $K_2SO_4$. Phosphorous rate was 34 P kg.$ha^{-1}$ for all N and K rates. Yield of marketable curds ($\geq$0.34 kg/curd) increased linearly and quadratically with increasing N rates from 0.1 t.$ha^{-1}$ with 0-N to 6.7 t.$ha^{-1}$ with 196 N kg.$ha^{-1}$. Early yields declined linearly and quadratically with increasing K rates ($P \leq 0.01$). Total yields were similar with all four K rates. Yields were higher at 30.5 than at 23.0-cm spacing ($P \leq 0.05$). At the 23-cm spacing 23% and at the 30.5-cm spacing 35% of the plants had marketable size and quality curds.

405

THE EFFECT OF VARIOUS RATES OF N AND S ON THE ASCORBIC ACID CONTENT OF LEAF LETTUCE

Melinda McVey McCluskey*, Ellen T. Paparozzi, and Julie A. Albrecht.
Departments of Horticulture and Nutritional Science and Hospitality Management, University of Nebraska, Lincoln, NE 68583-0724

Research previously conducted on leaf lettuce has shown that altering the amount of N and S applied had an effect on plant growth, color, N content and S content. The amount of N and S applied to the plant also affected consumer acceptance of leaf lettuce.

The leaf lettuce cultivar 'Grand Rapids' was grown hydroponically at 8 different treatment combinations consisting of four N levels (30, 60, 120, and 240 ppm) and three S levels (7.5, 15, and 120 ppm). Ascorbic acid content was determined immediately after harvest using the 2,6-dichloroindophenol method. Color was measured with a chromometer.

Results indicate that differences in ascorbic acid content could be detected between the various treatments. Plants which were darker green in color contained more ascorbic acid than plants yellow-green in color. Nitrogen applied had a significant effect on the ascorbic acid content while sulfur applied had no effect on ascorbic acid content of fresh leaf lettuce.

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# 178 ORAL SESSION 48 (Abstr. 406–413)
## Cross-commodity: Tissue Culture

406
SECONDARY SOMATIC EMBRYOGENESIS AND PLANTLET CONVERSION OF 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

Secondary embryos formed on somatic embryos that were placed on medium containing no PGRs (MS, 64.7% and DKW, 76.5%). Secondary embryogenesis was also observed when somatic embryos were in liquid MS (1μM NAA and 1 μM BA) on a shaker. Somatic embryos were placed on agar-solidified MS or DKW medium containing 1 μM TDZ or no PGRs. After 12 weeks, cotyledon expansion was observed on 41.2% (DKW, no PGRs) to 100% (DKW, 1 μM TDZ) of the embryos. Although cotyledons expanded, radicles and epicotyls elongated on very few somatic embryos. Epicotyl elongation primarily occurred on somatic embryos placed on agar-solidified MS with 1 μM IBA, 1 μM BA, and 3 μM TDZ and refrigerated (4°C) for 2 weeks or when somatic embryos were placed on liquid MS with 1 μM IBA, 1 μM BA, and 1 μM TDZ. Plantlets from somatic embryos survived in the greenhouse if epicotyls were excised and rooted ex vitro under mist or in high humidity trays.

407
ADVENTITIOUS MICROPROPAGATION OF RHODODENDRON 'P.J.M. HYBRIDS'
Marta E. Chytla* and John E. Preece, Department of Plant and Soil Science, Southern Illinois University at Carbondale, Carbondale IL 62901.

For genetic transformation studies, it is important that efficient adventitious regeneration systems be developed. In previous studies we had stimulated adventitious shoot formation from rhododendron leaf explants. To further determine which explants would be best to inoculate with Agrobacterium, we compared shoot organogenesis from small (2-4 mm long), medium (>4-8 mm long), and large (>8 mm long) leaves excised from in vitro shoot cultures. Across all reps (up to 66 explants), large leaves produced a mean of 23.4, medium produced 6.1, and small produced 2.2 adventitious shoots after 18 weeks. Adventitious microshoots were rooted in preformed peat plugs in high humidity flats. Prior to placement in the plugs, cut ends were treated with various combinations of IBA and NAA. After 8 weeks, control shoots rooted 60% and microshoots treated with 1.25 or 2.50 mM IBA plus 1.25 mM NAA or with a Wood's (1:20 dilution) solution rooted >95%.

408
VARIATION IN BIRCH PLANTS DERIVED FROM ORGANOGENIC CALLUS AND AXILLARY SHOOT PROLIFERATION
Ann M. Chanon* and R. Daniel Lineberger, Department of Horticultural Sciences, Texas A&M University, College Station TX 77843

*Betula* plantlets have been produced in vitro from axillary shoots, organogenic callus, and somatic embryos. Organogenic callus and somatic embryos involve cultural conditions that promote rapid, unorganized cell growth. The auxin 2,4-D is used frequently in these cultural systems. This study examined the effect of 2,4-D exposure on the ability to regenerate birch callus using thidiazuron (TDZ) and compared the subsequent rate of somaclonal variation in the plants produced via organogenesis and axillary shoot proliferation. Tissue which had not been exposed to 2,4-D differentiated shoots within five weeks after transfer to Woody Plant Medium containing $10^{-6}$M TDZ. Increasing the time of exposure to 2,4-D delayed differentiation. Calli exposed to 2,4-D for more than 18 weeks rarely differentiated shoots regardless of the concentration of TDZ used. Increasing concentrations of TDZ or increasing the time of exposure to TDZ increased the number of calli regenerating shoots. The most frequently observed somaclonal variation was albino shoots. The highest frequency of albino shoot production occurred in leaf tissue cultured directly on TDZ. Plants regenerated from callus and axillary proliferation were rooted, acclimated, and are being grown simultaneously in the greenhouse to allow estimation of other types of somaclonal variation.

409
*In vitro* Propagation of Kurrat (*Allium ampeloprasum*, var. Kurrat) and Leek (*Allium ampeloprasum* var. Porrum).
Yasseen Mohamed-Yasseen[1]*, Thomas L. Davenport[1], Walter E. Splittstoesser[2], and Robert M. Skirvin[2] University of Florida, IFAS, Tropical Research & Education Center, 18905 SW 280 St., Homestead, FL 33031

Kurrat and leek are popular Middle-eastern and European vegetables in the family Liliaceae. Explants were obtained by longitudinally slicing, 3 to 4 times, seedling stem bases of leek and kurrat or by making multiple longitudinal slices across the central axis of mature kurrat stem bases which were previously cross cut 1 cm above the bases. Some explants were cultured directly for shoot-induction in Murashige and Skoog (MS) medium containing 4.4 uM benzyladenine. Others were allowed to form callus in MS medium containing 1.4 uM 2,4-D and 1.4 uM kinetin before transfer to the shoot-induction medium. The number of regenerated shoots from callus was consistently higher than those placed directly in shoot-induction medium. Shoots formed roots in MS medium containing 1 g/l activated charcoal. All rooted plants established easily in soil.

410
IN VITRO REGENERATION IN ASCLEPIAS TUBEROSA L.
Sudeep Vyapari*, H. Khatamian, and M.L. Albrecht, Department of Horticulture, Forestry, and Recreation Resources, Kansas State University, Manhattan, KS 66506

Successful shoot and root morphogenesis was achieved in butterfly flowers (Asclepias tuberosa L.). Surface-sterilized nodal explants were initially pulsed in Murashige and Skoog (MS) medium supplemented with 2,4-D (2.0 mg/l) in combination with BA (0.1 mg/l) for one week. Organogenic calli transferred to MS medium containing BA or kinetin (2.0 mg/l) in combination with thidiazuron (0.01 mg/l) resulted in multiple shoot formation in 8-10 weeks. The cultures were incubated at 26°C under 16-hr photoperiod with 46 $\mu Em^{-2}.S^{-1}$ light.

Effect of number of weeks of 2,4-D pulse on induction of organogenic calli was also studied. One or two weeks of pulse treatment (2,4-D 2.0 mg/l and BA 0.1 mg/l) promoted 15 or more shoots in 60-80 % cultures in some treatments. Kinetin based medium maintained the organogenic potential of calli for a longer duration (16-18 weeks). Explants obtained from in vitro grown material induced more shoots than from the greenhouse grown liners. Rooting of the microshoots was best achieved in MS medium either supplemented with NAA (1.0 mg/l) or containing no hormones.

411
**Micropropagation of Endangered Succulent Plants:** *Aloe juvenna*, *Aloe volkensii*, **and** *Stapelia semota*.
Yasseen Mohamed-Yasseen*, and Thomas L. Davenport, University of Florida, IFAS, Tropical Research & Education Center, 18905 SW 280 St., Homestead, FL 33031

Many succulent plants are becoming endangered because of extensive collection and declining habitat. Shoot tips and stem nodes from mature plants of *A. juvenna* and *A. volkensii* were cultured in Murashige and Skoog (MS) medium containing 9.8 or 19.6 uM indolebutyric acid (IBA). Explants cultured in liquid medium produced two fold the number of shoots as those in agar medium. All regenerated shoots from Aloe explants produced roots directly to form microplants. Stem nodes of mature plants and of aseptically germinated seedlings of *Stapelia semota* were cultured in MS medium containing 1.1, 2.2, 4.4, or 8.8 uM benzyladenine and 0.1 uM naphthaleneacetic acid. Proliferation of subsequent shoots was achieved in the same media. Shoots rooted in MS medium containing 4.9 uM IBA. Microplants from both Aloe and Stapelia were successfully established in commercial potting soil.



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412

**FAST MICROPROPAGATION OF TUNA (Opuntia ficus-indica Mill.) AND PLANT ESTABLISHMENT IN SOIL**

Yasseen Mohamed-Yasseen*, and Thomas L. Davenport, University of Florida, IFAS, Tropical Research & Education Center, 18905 SW 280 St., Homestead, FL 33031

Methods for shoot multiplication, in vitro rooting, and ex vitro rooting of microcuttings are described. Regenerated shoots were formed from explants taken from young joints and flower receptacles when cultured in Murashige and Skoog (MS) medium containing 8.8 uM benzyladenine (BA) and 0.1 uM naphthaleneacetic acid (NAA). They were bisected into equal sections from apex to base and laid horizontally, cut-surface down on MS medium containing 4.4, 8.8, or 17.6 uM BA and 0.1 uM NAA. More than 10 shoots per section were regenerated within four weeks in plants cultured in the 8.8 uM BA medium. Resulting shoots were rooted *in vitro* in half-strength MS regardless of the presence of auxin or activated charcoal. *Ex vitro* rooting was accomplished by simply placing excised shoots upright in commercial potting soil. Virtually 100% of the plants were successfully established in soil from both rooting methods.

413

**SIMPLE IMPROVEMENTS FOR INCREASED EFFICIENCY OF RESEARCH MICROPROPAGATION LABORATORIES.**

Carl A. Huetteman* and John E. Preece, Department of Plant and Soil Science, Southern Illinois University at Carbondale, Carbondale IL 62901.

There are many ways in which small research or academic micropropagation laboratories can increase their efficiency. The standardization of stock solution aliquots and the use of repipetters for distribution greatly simplifies media preparation when using more than one medium or volumes of less than 1 liter. This is especially important if several graduate students and/or researchers are using the same laboratory and supplies. Peristaltic pumps are ideal for accurate dispensing of prepared media to culture vessels. A grocery-store type labeling gun can practically eliminate the use of marking pens for culture vessel identification. Colored tape may be used to determine visually the schedule for culture transfer to fresh media. Glass bead sterilizers are cooler and less damaging to transfer tools than bacticinerators. Commercially prepared peat plugs and high humidity flats provide a uniform environment for root development and acclimatization.

## 179 ORAL SESSION 49 (Abstr. 414–421)
## Floriculture: Water Stress/Water Utilization

414

**EFFECTS OF SOIL WATER LEVELS AND SUPPLEMENTARY LIGHTING ON PHYSIOLOGY OF TWO *Thymus vulgaris* CLONAL SELECTIONS.**

I. Photosynthesis, chlorophyll content and leaf water potential

W. Letchamo* H.L. Xu and A. Gosselin, Centre de recherche en horticulture, departément de phytologie, Université Laval, Québec, Canada G1K 7P4

*Thyme (Thymus vulgaris L.)* is an important medicinal and aromatic plant used in nutrition, pharmaceutical and cosmetic industries. The main objective of this investigation was to elucidate the influence of different growning conditions on photosynthesis, chlorophyll contnet and leaf water potential in two different thyme clonal selections. Pot experiments were conducted in a greenhouse with three different soil water levels (50, 70 and 90% by weight), under supplementary lighting and natural lighting. Photosynthetic rate was positively related to soil water level and supplementary lighting. Under both light treatments, photosynthesis was found to be highest at 70% soil water level. "Selection 1" showed higher rates of photosynthetsis than "Selection 2". "Selection 1" had slightly higher leaf water potential than "selection 2" under all growing conditions. Leaf water potential was found to be much higher for both selections grown without supplementary lighting than the variants grown under supplementary light. The mean chlorophyll content of "Selection 1" grown under supplementary lighting was found to be higher than "Selection-2" under all soil water levels (50 % 70% and 90%). There was a clear difference in leaf color between plants grown under the two light levels. This research was partially supported by Matol Botanical International.

415

**Growth and Stomatal Conductance of 'Amate' Schefflera Using Exterior Retractable Shading**

Sven E. Svenson* and Diane L. Johnston, Fort Lauderdale Research and Education Center, University of Florida - IFAS, 3205 College Avenue, Fort Lauderdale, FL 33314

Growth and stomatal conductance of Schefflera actinophylla (Endl.) Harms 'Amate' was studied in response to production shading environment. During two different growing seasons, plants grown under stationary shading (50% shade) had more shoot dry weight, were taller, and had larger stem diameters 2, 3, 4 and 5 months after potting, compared to plants grown without shading. Similarly, plants grown under retractable shading (50% shade) had more shoot dry weight, were taller, and had larger stem diameters than plants grown under stationary shading. There were no differences between plants grown under stationary or retractable shading after 5 months. Stomatal conductance of canopy-shaded foliage did not differ between plants grown under stationary or retractable shading when shading was extended or retracted. The increasing amount of foliage that becomes shaded by the canopy as the plant grows may limit the advantages of using exterior retractable shading.

416

**WATER USE EFFICIENCY AND GROWTH OF POINSETTIAS GROWN UNDER FOUR IRRIGATIONS SYSTEMS AND TWO FERTILIZER LEVELS**

John M. Dole*[1] and Sharon L. von Broembsen[2], [1]Dept. of Horticulture and Landscape Architecture and of [2]Plant Pathology, Oklahoma State University, Stillwater, OK 74078.

'Gutbier V-14 Glory' poinsettias grown with capillary mats (MAT) used the greatest amount of water and produced the most runoff, while plants grown with recirculatory subirrigation (RSI) used the least amount of water and produced the least runoff compared with microtube (MIC) and hand watering (HAN) systems. MIC and MAT systems required a greater number of irrigations to produce a crop than HAN and RSI systems. For the two overhead irrigation systems, MIC and HAN, plants grown with 250 mg liter$^{-1}$ had greater leaf, stem and root dry weights than those grown with 175 mg liter$^{-1}$. The two subirrigations systems, RSI and CAP, produced plants with greater leaf, stem and root dry weights when grown with 175 mg liter$^{-1}$ than with 250 mg liter$^{-1}$. Plants grown using CAP and HAN systems had higher leaf N concentrations than those grown with RSI and MIC systems. Overall, MIC plants grown with 250 mg liter$^{-1}$ were larger and of higher quality than the other treatments.

417

**MULCH AND IRRIGATION DELIVERY EFFECTS ON WATER MASS IN MM 350 AT SATURATION (SWHC), CONTAINER CAPACITY(CCWHC), AND AFTER IRRIGATION (EWHC).**

N.S. Khoury*, E.J. Holcomb, and J.W. White, Horticulture Department, 103 Tyson Building, Penn State, University Park, PA. 16802

A 2 by 4 factorial design was used to determine the effect of 4 mulches (Plastic cover, hydrophilic polymer, rockwool and none) and 2 irrigation delivery methods (surface and subirrigation) on the mass of water in MM 350 at saturation, container capacity and after irrigation on 4, 5 and 6 inch standard pots. An analysis of covariance was conducted with pot volume as the covariant.

With all treatments SWHC>CCWHC>EWHC. No significant differences resulted for SWHC with any mulch treatment or irrigation delivery method. There was no significant difference in CCWHC if either sub irrigated or surface irrigated for the same mulch. When subirrigated, gel mulch results in significantly more CCWHC than the plastic mulch - subirrigated treatment or the no mulch - surface irrigated - treatment.

Higher EWHC resulted when pots were surface irrigated. No mulch resulted in the lowest mass of water when either surface or sub irrigated. When subirrigated, no significant difference in water mass after irrigation resulted among either the gel, plastic or rockwool mulches.



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418

OSCILLATORY TRANSPIRATION IN *ROSA HYBRIDA* 'MOONLIGHT'

Mark A. Rose*, David J. Beattie, and John W. White, Department of Horticulture, The Pennsylvania State University, University Park, PA 16802

Two distinct patterns of whole-plant transpiration were observed in potted roses using an acquisition network that integrated a Dansk Gartneri Teknik climate computer, Dynamax heat-balance sap-flow gauges, Fisher electronic-balance lysimeters, and Everest infrared leaf temperature sensors. One pattern consisted of a steady rate of transpiration in a stable greenhouse environment. The second pattern consisted of large oscillations in transpiration that were unrelated to any known microclimate rhythms. These oscillations had a sine-wave pattern with periods between 60-90 minutes and ranges between 3 and 37 $g \cdot hr^{-1}$ in natural light and 2 and 69 $g \cdot hr^{-1}$ in artificial light during the night. Leaf temperatures also oscillated, but were inversely related to the transpiration cycles. Oscillatory transpiration has not been reported in roses.

Oscillatory transpiration is an example of the phenomena that may now be investigated by integrating climate computers and sensors that monitor plant physiological processes. When plant responses to microclimate variables can be predicted and monitored in real time, the 'speaking plant approach' can be used, in which plants directly control their greenhouse environment.

419

SCHEDULING IRRIGATION FOR GREENHOUSE PRODUCTION OF CUT ROSES IMPROVES QUALITY AND WATER USE

Steven E. Woerner* and Douglas A. Hopper, Department of Horticulture, Colorado State University, Fort Collins, CO 80523

Four irrigation scheduling techniques for greenhouse production of three cultivars of hybrid tea rose, *Rosa hybrida* L., were examined for their effect on bloom quality. The irrigation scheduling techniques examined in this study included: a time clock based method; an accumulated radiation based method; an accumulated vapor pressure deficit (VPD) based method; and a combination method, which used an accumulated combination of VPD and radiation. Results from the study indicate that roses grown under the time clock method were poorer in length, fresh weight and dry weight. The other three treatments did not differ in a discernable pattern for their effect on quality. We hypothesize that the time clock method, while supplying as much or more water, was not able to apply water at the *right time*.

The three non-control treatments differed significantly in the amount of water that they applied to benches, as the VPD method supplied as much as 60% less water during the Valentine's Day period, and as much as 80% less water during the Mother's Day harvest, without reductions in quality. These differences were mainly due to the selection of the irrigation event threshold values.

420

LEVEL AND FREQUENCY OF WATER STRESS DURING FORCING AFFECT FLOWERING OF 'GLORIA' AZALEAS

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

Dormant-budded 'Gloria' azaleas (*Rhododendron* sp.) were used to determine the effect of water stress level and frequency during forcing. Budded plants were cooled at 2°C for 6 weeks, then placed in a fan and pad cooled greenhouse for forcing. Plants were thoroughly watered then allowed to dry 1, 2, or 3 times to -15 or -25 bars during forcing. Stress to -25 bars 2 or 3 times delayed time to marketability (8 open-flowers) by 3 and 11 days, respectively, and reduced flower diameter by 7% and 18%, respectively. Increasing stress levels (-15 to -25 bars) delayed marketablility up to 4 days and reduced flower diameter up to 9%. Increasing number of stress periods (1, 2, or 3 times) delayed marketability up to 6 days and decreased flower diameter up to 10%. Stress levels of -15 and -25 bars increased the percent of buds showing color by 11% and 21%, respectively, at 8 open flowers. Increasing number of stress periods increased buds showing color by 10%, 15% and 23%, respectively. Stress level and number of stresses did not have synergistic effects on percent of buds showing color.

421

EFFECTS OF NITROGEN APPLICATION RATES AND IRRIGATION SETPOINTS ON NITRATE LEACHING AND LEATHERLEAF FERN

Robert H. Stamps, Univ. of Florida, Inst. of Food and Agr. Sci., Central Fla. Res. and Educ. Center, 2807 Binion Road, Apopka, FL 32703

Leatherleaf fern (*Rumohra adiantiformis*) was grown in 36 in-ground 1.2 m × 0.6 m × 0.9 m lysimeters located in a shadehouse fernery to determine the effects of nitrogen application rate (392, 532, 672 or 812 kg $N \cdot ha^{-1} \cdot yr^{-1}$) and irrigation setpoint (-8, -12 or -16 kPa soil moisture tension) on nitrogen leaching and fern frond yield (number and weight) and quality (color and vase life). Liquid fertilizer was applied more or less weekly as is done commercially. Average $NO_3$-N concentrations in leachate from the lysimeters were below the 10 mg $NO_3$-N/l maximum contamination level only for the 392 kg $N \cdot ha^{-1} \cdot yr^{-1}$ treatment; however, maximum leachate $NO_3$-N concentrations ranged from 29 at the lowest N rate to 65 mg/l at the highest rate. Irrigation setpoint did not affect leachate $NO_3$-N concentrations. Treatments had no effect on number of fronds produced or frond average weight, color or vase life. These results suggest that reduced N fertilization rates (approximately ½ the current commercial rate) could be used successfully to produce leatherleaf fern if similar fertilization and water management practices were employed.

## 180 ORAL SESSION 50 (Abstr. 422–428)
## Cross-commodity: Postharvest

422

EFFECT OF PERFORATED FILM PACKAGES ON STORAGE OF ASPARAGUS

Robert C. Herner, Dept. of Hort., Mich. State Univ., E. Lansing, MI 48824

Some horticultural crops have very high respiration rates which makes it difficult to develop modified atmosphere packages that will prevent the product from being injured by high $CO_2$ or from injury by low $O_2$ or anaerobic conditions. Asparagus has a very high respiration rate and responds well to relatively high $CO_2$. Oxygen concentration is less important providing that the asparagus does not go anaerobic.

This investigation reports the results of holding asparagus at 0 C in packages of 3 film thicknesses (1,2 or 3 mil LDPE) and varying the number of holes from 0 to 16 per package. Five hundred grams of asparagus was held up to 4 weeks. Carbon dioxide and oxygen inside the packages was monitored as well as the quality of the asparagus.

423

CITRUS FRUIT WITH LOW SHRINKAGE RATE

Robert D. Hagenmaier* and Robert A. Baker, USDA, ARS, Citrus and Subtropical Products Lab., P.O. Box 1909, Winter Haven, FL 33883-1909

Citrus fruit was coated twice, using two different wax microemulsions composed of FDA-approved ingredients. Oranges, grapefruit and tangerines thus coated exhibited shrinkage rates less than 50% those of fruit coated in commercial packinghouses. Internal $CO_2$ of double-coated fruit was lower than packinghouse fruit, thus suggesting that gas exchange was not overly restricted. The double-coated fruit had good gloss.

424

INTERNAL CARBON DIOXIDE AND ETHYLENE LEVELS IN TOMATO FRUIT RIPENING ATTACHED TO OR DETACHED FROM THE PLANT

Mikal E. Saltveit, Jr., Mann Laboratory, Department of Vegetable Crops, University of California, Davis, CA 95616-8631

The internal concentration of $CO_2$ and $C_2H_4$ and the stage of ripeness was periodically measured in tomato fruit (*Lycopersicon esculentum* cv. Castelmart) attached to and detached from the plant. An external collection apparatus permitted nondestructive sampling of internal gases. The concentration of $CO_2$ and $C_2H_4$ in the collection apparatus had equilibrated with the internal gas concentrations after 18 hr. A 20-fold increase in $C_2H_4$ during ripening of detached tomato fruit was paralleled by a 3-fold increase in $CO_2$ concentration. Ripening attached fruit exhibited a 100-fold rise in $C_2H_4$ during ripening, but lacked a ripening associated climacteric rise in $CO_2$. $CO_2$ did increase 2-fold in an erratic fashion during ripening of attached fruit, but the increase did not show any correspondence to increased $C_2H_4$ or ripening associated color changes. In tomato fruit, it appears that a $CO_2$ climacteric *per se*, which has been considered an intrinsic quality of certain ripening fruit, may not be necessary for the ripening of "climacteric" fruit at all, but may instead be an artifact of using harvested fruit.



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425

MODIFIED-ATMOSPHERE PACKAGING OF SMALL FRUITS: THE INFLUENCE OF $CO_2$ ON $O_2$ UPTAKE AND THE LOWER $O_2$ LIMIT

Dennis W. Joles*, P. Chowdary Talasila and Arthur C. Cameron, Dept. of Horticulture, Michigan State University, E. Lansing, MI 48824-1325

For raspberry (*Rubus idaeus* L. 'Heritage'), blueberry (*Vaccinium corymbosum* L. 'Jersey') and sweet cherry (*Prunus avium* L. 'Sams') fruit, CaO, as a $CO_2$ scrubber, was combined with modified-atmosphere packaging to generate a range of steady-state $O_2$ levels (≈13 to 1 kPa) over which $CO_2$ accumulated (≈3 to 17 kPa) or was scrubbed (≤ .1 kPa). The steady-state $O_2$ levels in the presence and absence of generated $CO_2$ were similar. Since steady-state $O_2$ levels are a direct function of a fruit's $O_2$ uptake in a modified-atmosphere package, we concluded that the $CO_2$ levels generated had no effect on $O_2$ uptake. The $O_2$ level at which an increase in headspace ethanol was observed also did not differ in packages with and without a $CO_2$ scrubber. For raspberry fruit, supplemental $CO_2$ levels of 10, 20 and 60 kPa were added to sealed packages. The levels of steady-state $O_2$ and $CO_2$ were measured and the rates $O_2$ uptake and $CO_2$ production estimated. It was found that supplemental $CO_2$ levels up to 20 kPa had little effect on fruit $O_2$ uptake.

426

HOT WATER TREATMENT IMPROVES TOMATO SHELF LIFE

T.G. McCollum* and R.E. McDonald, USDA, ARS, U.S. Horticultural Research Laboratory, 2120 Camden Rd., Orlando, FL 32803

Mature, green tomatoes were immersed in heated water (42, 44, 46, or 48C) for up to 90 min, and then either not cooled or cooled in water or a solution of 2% $CaCl_2$ prior to storage at 2.5C. Following 2, 3, or 4 weeks of storage, the fruit were transferred to 21C for ripening. During ripening, the fruit were evaluated for color development, defects, and decay. Following storage, fruit required ca. 3 weeks at 21C to ripen regardless of storage duration. The number of fruit that developed acceptable market quality decreased as time at 2.5C increased; however, treated fruit tended to retain better condition than did nontreated fruit. Hydrocooling the fruit either in water or $CaCl_2$ did not appear to be beneficial. The major cause of fruit loss was decay. All hot water treatments inhibited decay and resulted in a greater number of fruit with acceptable quality compared with nontreated fruit. Hot water treatment appears to be a beneficial treatment for maintaining tomato fruit quality.

427

RIPENING OF TOMATO FRUIT LOCULE GEL TISSUE

Mordy A. Atta-Aly, Jeffrey K. Brecht*, and Donald J. Huber, *Horticultural Sciences Dept., Univ. of Fla., Gainesville, FL 32611-0690*

Ethylene production by locule gel tissue excised from full-size immature- and mature-green tomato fruit was inhibited by exposure to 100$\mu l \cdot l^{-1}$ $C_2H_4$, and ACC content was reduced. In contrast, $CO_2$ production, EFE activity, red color development, and tissue liquefaction were stimulated by $C_2H_4$, and, in immature gel, the onset of autocatalytic $C_2H_4$ production was hastened. The autoinhibition of $C_2H_4$ production required continuous exposure to $C_2H_4$, as transfer to air and then back to $C_2H_4$ resulted in $C_2H_4$ production first increasing to control levels, then decreasing again. Locule tissue from pink fruit responded to $C_2H_4$ treatment with increased production of both $C_2H_4$ and $CO_2$, but ACC levels were unchanged. Inhibition of $C_2H_4$ action by pretreatment with STS inhibited both autoinhibition of $C_2H_4$ production in immature gel and autocatalytic $C_2H_4$ production in mature tissue. These results indicate that there is a transition from a negative to a positive feedback mechanism of $C_2H_4$ on $C_2H_4$ biosynthesis in locule gel during ripening. Additionally, this feedback mechanism, which involves ACC synthase, is apparently under separate control from the other manifestations of $C_2H_4$ action.

428

THE EFFECTS OF MODIFIED ATMOSPHERE PACKAGING AND TEMPERATURE ON POSTHARVEST STORAGE LIFE OF HOT PEPPERS (Capsicum frutescens L.)

Majeed Mohammed*, L.A. Wilson and P.I. Gomes, Department of Crop Science, University of the West Indies, Trinidad, W.I.

Two cultivars of hot peppers were stored under various $O_2$ and $CO_2$ regimes generated using modified atmosphere packaging techniques at 5°, 10°, 20° and 30°C. Hot peppers treated with a bactericide and packaged in microperforated high density polyethylene (HDPE) bags stored best at 10°C with the level of decay-free fruits at 96.1% after 25 days. Incipient chilling injury (CI) without visible symptoms after short storage periods at 5°C was detected both by reduced bioelectrical resistance, and increased electrolyte leakage. The severity of CI progressed more rapidly when fruits, sealed in micro-perforated HDPE bags and stored for 30 days at 5°C were transferred to 28-30°C for 1, 3, or 5 days respectively. The detrimental effects of increasing $CO_2$ and $C_2H_4$ concentrations within packages particularly upon transfer to elevated temperatures contributed to the severity of the symptoms.

## 183 WORKSHOP 18 (Abstr. 429–430)
## Domesticating Woodland Plants

429

GINSENG CULTIVATION AND PHYSIOLOGY

John T.A. Proctor, Department of Horticultural Science, University of Guelph, Guelph, Ontario, Canada, N1G 2W1.

Ginseng is an herbaceous perennial that is cultivated for its highly valued root. It is used as a cure-all, wonder drug and aphrodisiac, the active principles being saponins (ginsenosides). The essential features of the cultural system are shade, a mulch and the growing of plants on raised beds. The plants are obtained either by direct seeding or by seeding into a nursery bed and transplanting. The established crop requires spraying for diseases, insects and weed control. Although ginseng has been cultivated in North America for over 100 years associated research on mechanisms controlling growth and development of the plant has been minimal. Crop establishment is a highly vulnerable stage in the life cycle of ginseng growing yet we know little about fruit and seed set, seed quality, stratification and germination. The growing environments for ginseng have only recently been precisely defined. However, we need to know more about environmental variables and their inter-relationship particularly in relation to photosynthesis and dry matter partitioning. Disease control is the central problem in world ginseng production and requires an integrated approach.

430

GOLDENSEAL: CULTIVATION OF A RARE BOTANICAL

Jeanine M. Davis*, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695.

Goldenseal (*Hydrastis canadensis* L.), a native herbaceous perennial, is a highly valued medicinal herb which has been collected from the forests of the eastern United States for generations. Used to treat a wide variety of disorders ranging from sore throats to cancer, its pharmacological properties are attributed to the alkaloids hydrastine and berberine. Due to its popularity, native goldenseal populations have been seriously depleted in some areas. In North Carolina, for example, goldenseal is classified as an endangered species, making collection from the wild illegal. To meet the increasing demand and prevent further depletion of native populations, goldenseal cultivation is being tested and encouraged. Goldenseal cultivation is similar to that of ginseng, although somewhat easier because goldenseal is less prone to disease than ginseng. Goldenseal can be grown under natural forest canopy or under artificial shade. It is easily propagated by rhizome divisions or rootlet cuttings. It can also be propagated by seed, which must be kept moist and stratified before germinating the spring following harvest. Seed grown plants are ready to harvest in four or five years; plants grown from rootlets or rhizome divisions may be harvested in three or four years.



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# 184 WORKSHOP 19 (Abstr. 431–434) Computer Modeling of Crop Growth and Development

431

INTRODUCTION TO COMPUTER MODELLING

Milton E. McGiffen, Jr.*, Department of Botany and Plant Sciences, University of California, Riverside, CA 92521-0124.

Computer modelling uses mathematical relationships to characterize a complex system. There are several reasons for using mathematical modelling in crop production: 1) Models serve as a framework to bring together and order our concepts of an agricultural system, 2) Many processes are so dynamic that they cannot be adequately measured in the field, but can be examined with models, 3) Once a model has been built, it can be used as a tool to study problems that would be difficult to approach experimentally, and 4) Computer modelling often results in software that can be made interactive and user-friendly for wide distribution. Different methods of computer modelling include regression, simulation, and the systems-oriented approach. Regression is the most widely used approach, and is good for developing simple relationships from experimental data. However, regression models are often oversimplified and may not transfer well. Simulation models are built from many subroutines of individual processes that are linked to simulate a complex problem, such as the physiology of crop growth. A systems approach uses a variety of techniques to help users meet predetermined management goals.

432

PRINCIPLES OF MODELING CROP GROWTH AND DEVELOPMENT, MODEL TYPES, TECHNIQUES, AND SIMULATION

Kent D. Kobayashi, Department of Horticulture, University of Hawaii at Manoa, Honolulu, HI 96822 USA

Crop modeling encompasses the use of mathematics, statistics, and equations to describe quantitatively crop growth and development. It can be useful tool to describe, quantify, and predict crop growth, development, and phenology. Crop models fall into two general classes—statistical (empirical) or mechanistic (physiological)—or they may be a combination of the two. The model type depends upon several factors including the objectives of the modeler, understanding of underlying physiological processes, and availability of data. Model development proceeds from a preliminary conceptual model through formalization into a mathematical model. Models are later verified, and validated, if possible. Model development is an iterative process with continual refinement as more data becomes available and understanding increases. Simulations are dynamic models that follow the growth and development of crops over time. They are more mechanistic in nature and involve changes in measurable quantities of the crop as affected by changes in rates of physiological processes.

433

BIOECONOMIC WEED MANAGEMENT MODELS

Frank Forcella*, USDA-ARS, Morris, MN 56267; Robert King, Univ. of Minnesota, St. Paul; Lori Wiles, USDA-ARS, Fort Collins, CO; Douglas Buhler, USDA-ARS, St. Paul, MN; Scott Swinton, Michigan St. Univ., East Lansing; Jeffrey Gunsolus, Univ. of Minnesota, St. Paul; and Bruce Maxwell, Montana St. Univ., Bozeman.

Bioeconomic weed management models integrate the complex interactions of the biology of crops and weeds, efficacies and costs of chemical and mechanical weed control options, and commodity prices of crops. These models enable producers to customize weed management strategies so that weed control and crop yields are optimized while net economic returns are maximized. A prototype model, WEEDSIM, was developed (Swinton & King) for corn and soybean production. It was field-tested for two years in Minnesota. WEEDSIM's recommendations were agronomically equivalent to standard farmer practices, but they increased net financial returns and reduced chemical release to the environment. A new bioeconomic modeling "shell" has been developed (Wiles & King) to increase adaptability to new crops, weeds, control options, and production regions.

434

FARMBOOK: A WHOLE-FARM INFORMATION SYSTEM

Sam Alessi*, USDA-Agricultural Research Service, North Central Soil Conservation Research Laboratory, Morris, MN; Leng Vang, Univ. of Minnesota, Morris, MN; Ward Voorhees, USDA-Agricultural Research Service, North Central Soil Conservation Research Laboratory, Morris, MN.

**Agricultural research has produced many results that can be useful to crop managers. Viewed as a whole, these results are often difficult to apply in concert to a production system. Farmbook is an attempt to integrate research results through a primarily software-driven information management environment. Farmbook first provides an infrastructure for simulation modeling and expert systems by building upon detailed and individualized crop records. This infrastructure must first be easy to use and provide basic information such as production costs, nutrient summaries and yield analysis. Building such a system involves problem analysis and design prior to programming. Data modeling, data flow diagramming, state-transition modeling and object-oriented design have been used to build a Farmbook prototype. Farmbook was tested by farmers on 12 farms in 1992. The flexibility of the system should allow direct application to horticultural crop or greenhouse environments.**

# 185 WORKSHOP 20 (Abstr. 435–437) Strategies to Develop Virus-resistant Fruit Cultivars

435

PRODUCTION OF TRANSGENIC *CITRUS* PLANTS EXPRESSING THE CITRUS TRISTEZA VIRUS COAT PROTEIN GENE

Gloria A. Moore*, Alejandra Gutiérrez-E., Colette Jacono, Michael McCaffery and Kenneth Cline, Horticultural Sciences Department, Institute of Food and Agricultural Science, University of Florida, Gainesville, FL 32611

Citrus tristeza virus (CTV) is the most devastating citrus virus worldwide. Studies in a number of laboratories have shown that protection against a virus may be achieved by the introduction of the cloned viral coat protein (CP) into transgenic plants. The CTV CP has been isolated and sequenced [Sekiya et al., J. Gen. Virol. (1991) 72:1013-1020] and cloned into a custom engineered plant expression vector [Slightom JL, Gene (1991) 100:251-255]. We have also developed a protocol for the *Agrobacterium*-mediated transformation of internodal stem sections of *Citrus* seedlings [Moore et al., Plant Cell Rep. (1992) 11:238-242]. Transgenic plants of Carrizo citrange [*C. sinensis* (L.) Osb. x *Poncirus trifoliata* (L.) Raf.] and sour orange (*C. aurantium* L.) expressing the CTV CP gene have been identified based on ß-glucuronidase expression, PCR and Southern analyses, and immunoblot analysis with antibody to the CP. Transgenic sour orange plants are being propagated to generate sufficient material to test whether the plants are resistant to challenge by CTV.

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**TRANSFORMATION OF PLUM (PRUNUS DOMESTICA L.) WITH POTYVIRUS COAT PROTEIN GENES AND THE REACTION OF TRANSGENIC PLANTS TO INOCULATION WITH PLUM POX VIRUS**

**R. Scorza*[1], L. Levy, V. Damsteegt, M. Yepes, J. Cordts[1], A. Haddidi, J. Slightom, D. Gonsalves, A. Callahan[1] and M. Ravelonandro, [1]USDA/ARS Appalachian Fruit Research Station, 45 Wiltshire Road, Kearneysville, WV 25430**

**Plants transgenic for potyvirus coat protein (cp) genes have been shown to be resistant to viruses homologous and heterologous to the cp source virus. We have produced plum plants transgenic for the papaya ringspot virus (PRSV) cp gene. PRSV is a potyvirus related to plum pox virus (PPV). PRSVcp transgenic plants have been inoculated with PPV under containment conditions at the USDA Foreign Diseases-Weed Science Research Facility, Frederick, MD, and evaluated for two years. At least one plant is apparently resistant or tolerant to PPV based on symptomology, ELISA and RT-PCR assays. This suggests the potential utility of cp-mediated virus protection in tree fruits. To further test this**



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**potential, both short and long-term studies are in progress to evaluate resistance and cp expression in various organs, throughout the year and over the commercial life of individual trees. Plum plants have also been transformed with the PPVcp gene. Studies are underway to evaluate the protection derived from this cp gene.**

437
COAT PROTEIN-MEDIATED RESISTANCE AGAINST APPLE MOSAIC VIRUS INFECTION
Schuyler S. Korban*, Department of Horticulture, 310 PABL, University of Illinois, 1201 W. Gregory, Urbana, IL 61801

Apple mosaic virus (ApMV) is transmitted by grafting to various *Rosaceae* plants including apple, rose, and plum, among others. ApMV reduces apple tree growth, yield, and fruit size; it causes mosaic symptoms on rose, and line patterns on plum and birch. ApMV is a member of ilarviruses, and it is characterized as isometric, labile, and producing ring spots. ApMV is a tripartite virus; RNA1 and RNA2 are monocistronic; whereas RNA3 contains two cistrons, one of which is the coat protein. The coat protein is translated from a subgenomic messenger, RNA4, which is derived completely from RNA3. We isolated and purified ApMV; virions containing RNA3 and RNA4 were separated from those containing RNA1 and RNA2. The sizes of RNA1 and RNA2 were estimated equal to 3 kb and 2.7 kb, respectively; the sizes of RNA3 and RNA4 were estimated equal to 2 kb and 0.9 kb, respectively. Inserts of clones from the 3'-end of RNA3 were sequenced and the 3'-primer was used to synthesize cDNA of RNA3. Overlapping cDNA clones were used to determine the nucleotide sequence of RNA4. Characterization and sequencing of the coat protein gene as well as transfer of this gene into apple will be discussed.

## 186 WORKSHOP 21 (Abstr. 438–439) Economic Impacts on Changing Markets Due to Public Perceptions: Floriculture, Turfgrass, Landscape, and the Wine Industry

438
CONSUMER RESEARCH IN THE FLORAL INDUSTRY
B.K. Behe*, Department of Horticulture and Alabama Agricultural Experiment Station, 101 Funchess Hall, Auburn University, AL 36849-5408

Worldwide floral sales exceed $25 billion annually and the U.S. ranked 12th of 15 countries in per capita floral consumption. The objective of this paper is to summarize published consumer research in the floral industry. Floral purchases are often correlated to demographic characteristics. Age and income are positively correlated to floral expenditures. Research has investigated differences in purchasing behavior by gender and nationality. Studies have documented consumer preferences for flower and color preferences. Consumer purchase frequency and retailer patronage have also been investigated. Multivariate analyses have enabled researchers to relate many variables simultaneously to floral purchases yielding market segments and perceived product value. Consumer research in the floral industry began in 1956, yet less than 100 studies have been published to date.

439
ECONOMIC IMPACTS ON CHANGING MARKETS DUE TO PUBLIC PERCEPTIONS: TURFGRASS AND LANDSCAPE
William H. Culpepper*, Director of Government, Public and Industry Affairs for DowElanco, 9002 Purdue Road, Indianapolis, IN 46268

Turfgrass and landscape combine to form the surroundings for, not only our homes, parks, and recreational areas, but the workplace in which we spend much of our time. Home lawns, roadsides, parks, golf courses, and common areas are important as places for play and relaxation for children and adults as well. This desire for a more beautiful, natural surrounding has led to a continuing growth in the demand for both products and services for the turfgrass and landscape industry. Better maintained turfgrass and landscape benefit the public in four ways: 1) personal gardening satisfaction 2) aesthetics 3) property value enhancement 4) an environmentally friendly cover for the soil. To obtain these benefits, research and industry have combined to provide a continuing stream of enhancement. This paper discusses the benefits the American public receives from turfgrass and landscape, and attempts to quantify their value and future direction.

## 187 WORKSHOP 22 (Abstr. 440–442) Modeling Photosynthesis and Carbon Partitioning

440
MECHANICS OF MODEL BUILDING
James M. McKinion, USDA-ARS Crop Simulation Research Unit, P. O. Box 5367, Mississippi State, MS 39762-5367

In the late 1960's with the advent of wide availability of the digital computer, it became possible through the application of systems theory to build simulation models of biological entities. In production agriculture, scientists have built models of a number of field crops: cotton, corn, wheat, soybean, and alfalfa. In most of the models built to date, crop phenology is addressed directly with detailed aspects of crop physiology and/or soil physics addressed either to a greater or lessor degree. This paper addresses the methodology of the construction of process-level, physiologically-based crop simulation models which possess detailed descriptions of plant physiological and soil physical mechanisms and proposes a minimum set of design features.

441
MODELING PHOTOSYNTHESIS AND CARBON PARTITIONING IN ROW CROPS
K. J. Boote* and N. B. Pickering, Agronomy Dept., Univ. of Florida, Gainesville, FL 32611.

Many horticultural crops are grown in rows rather than in horizontally-uniform stands. Thus it is important to be able to model light interception and photosynthesis of incomplete hedgerow crops. In our model, absorption of direct and diffuse irradiance by incomplete hedgerow canopies is computed as a function of canopy height, width, leaf area index (LAI), leaf angle, row direction, latitude, day of year, and time of day. A sunlit versus shaded LAI approach is used to compute absorption of photon flux density (PFD) by sunlit versus shaded leaves. Canopy assimilation is the sum of sunlit and shaded leaf rates over their respective LAI classes. Photosynthesis of sunlit and shaded leaves is computed with the asymptotic exponential equation, with quantum efficiency and light-saturated rate terms being made sensitive to intercellular $CO_2$ ($C_i$), $O_2$, and temperature. Farquhar and van Cammerer equations are used to compute the efficiency of electron conversion to $CO_2$ fixation. Stomatal conductance depends on leaf rate and $C_i$ to $C_a$ ratio. Examples of canopy assimilation response to PFD, $CO_2$, temperature, and LAI will be illustrated for incomplete canopies, with and without canopy energy balance.

442
A SUPPLY AND DEMAND APPROACH TO MODELING ANNUAL REPRODUCTIVE AND VEGETATIVE GROWTH OF DECIDUOUS FRUIT TREES
Theodore M. DeJong and Yaffa L. Grossman, Dept. of Pomology, University of California, Davis, CA 95616

An approach to developing a simulation model of the annual carbon supply and demand for reproductive and vegetative growth in peach trees will be presented. This modeling approach simulates photosynthetic carbon assimilation using seasonal canopy light interception and daily minimum and maximum temperature and solar radiation inputs. Simulation of carbon partitioning and crop growth is based on the hypothesis that plants grow as collections of semi-autonomous, but interacting organs. The plant genotype, triggered by internal and environmental signals, determines current organ specific growth potentials. Daily environmental conditions interact with organ specific growth potentials to determine the conditional growth capacity and



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maintenance respiration requirement (i.e. the carbon demand) of each organ type. Then the daily carbon available for growth after maintenance requirements are met is partitioned to leaves, fruits, stems, and branches based on their relative conditional growth capacities. Remaining carbohydrate is partitioned to the trunk based on its conditional growth capacity and all residual carbohydrate is partitioned to roots after above-ground demands are met. The methods used to determine organ specific growth potentials and the usefulness of using the supply and demand approach to modeling the carbon economy of deciduous fruit crops will be discussed.

## 188 WORKSHOP 23 (Abstr. 443–445)
## Regional Status of Drip Irrigation Usage for Commercial Vegetable Production in the United States

443

DRIP IRRIGATION OF VEGETABLE CROPS IN THE SOUTHWEST

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

The use of drip irrigation in the production of vegetable crops has expanded rapidly in the Southwest in the last decade. The factors contributing to this conversion are: a) water availability and cost, b) improved design and production of drip irrigation products which has dramatically improved performance and reliability, c) reduced cost of drip irrigation in relation to other crop production costs, and d) development of integrated management practices which maximize crop productivity and system performance. Regionally, more than 30,000 ha of vegetable crops are produced annually using drip irrigation, the majority of which is in California; major commodities are tomato, pepper, melons and salad crops. Many different types of drip installations have been evaluated. The trend in new installations is toward buried systems in semi-permanent beds, with multiple crops being produced before system renovation. Specialized management practices are evolving which make such systems highly efficient.

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DRIP IRRIGATION USAGE IN THE MIDWESTERN UNITED STATES

W. J. Lamont, Jr., Department of Horticulture, Forestry and Rec. Res., Kansas State University, Manhattan, KS 66506

Drip irrigation used in conjunction with plastic mulches and other intensive production technologies continues to expand in the Midwestern states. The vegetable crops being produced on the greatest acreages using drip irrigation/plastic mulch are tomatoes, peppers, muskmelons and watermelons. Summer squash, eggplant, cucumbers and some cole crops are also grown using drip irrigation and plastic mulches but to a much lesser extent. The estimated acreage for drip irrigation in the Midwest is 43,209 acres which includes both vegetable and fruit crops.

Special consideration in using drip irrigation in this region of the country are high pH of the water, amounts of calcium salts, and iron levels in the water.

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DRIP IRRIGATION OF VEGETABLE CROPS IN THE SOUTHEASTERN U.S.

George Hochmuth* Horticultural Sciences Department, 1143 Fifield Hall, University of Florida, Gainesville, FL 32611-0690

Microirrigation (drip or trickle) is part of intensive vegetable production employed in the humid southeastern part of the U.S. Drip irrigation is increasing in importance for vegetable irrigation because growers can achieve irrigation water savings of about 50% for many vegetables and growers can more efficiently apply fertilizers and labeled agricultural chemicals with drip irrigation. In Florida, more than 10,000 ha of vegetables including tomatoes, peppers, watermelons, eggplants, cucumbers, and squash are irrigated with drip irrigation and this acreage increases every year. With the increasing pressure from urbanization and concern for environmental issues, water quantity and quality are prime considerations in vegetable farming. Drip irrigation will continue to be an important tool for managing water quantity and quality on the vegetable farm. This workshop paper will present the current status of drip irrigation practices used on commercial vegetable crops in the southeastern U.S.

## 190 WORKSHOP 25 (Abstr. 446–449)
## Organogenesis, Embryogenesis, and Tissue Culture Procedures and Their Implications for Automation of Micropropagation

446

STATUS OF AUTOMATION IN RELATION TO PLANT MICROPROPAGATION

Albert Liptay, Agriculture Canada, Research Station, Harrow, Ontario , N0R 1G0 Canada

Micropropagation (MP) via tissue culture may include propagation from a bud on the mother plant, organogenesis, i.e., plantlet formation from a piece of tissue from the mother plant, or somatic embryogenesis, i.e., formation of a new embryo from a cell or group of cells. While MP may involve species-dependent problems, automation of MP exhibits problems depending on which manner of propagation is selected. Currently, most commercial MP is done via organogenesis. However, because of the potential for very large numbers of new plantlets derived through somatic embryogenesis at reasonable costs, there are numerous efforts attempting automation of MP of somatic embryogenesis. A number of species exhibit somatic mutation during the process of somatic embryogenesis and species-specific techniques have to be found to reduce or eliminate these and other problems. Automation of MP through meristem isolation of organogenesis is one way of overcoming the somatic mutation problems associated with somatic embryogenesis. This paper outlines the physiological and technical problems associated with automation of MP.

447

DEVELOPMENTAL PHYSIOLOGY OF SHOOT FORMATION FROM VARIOUS EXPLANT SOURCES

Ellen Sutter, Department of Pomology, University of California, Davis, CA 95616

Most micropropagation (MP) is based on meristem or shoot tip culture, methods thought to result in a lower incidence of genotypic and phenotypic alterations than methods that proceed through callus first. The use of somatic embryogenesis, especially as artificial seed, is promising because of the very large numbers of propagules that may be produced from an initial explant. A limiting factor in the commercial utilization of MP has been the high labor cost. The use of automation could reduce costs and increase productivity using MP techniques. Each MP method has positive and negative aspects associated with it. In shoot production from non-apical meristematic tissue, time to form shoots, chance of off types, and ability of the automated system to distinguish developing tissue from desirable shoot propagules could limit application of automation. Somatic embryogenesis suffers from varied degrees of phenotypic and genotypic alterations as well as from difficulties in germinating embryos. We will survey several of these difficulties in terms of the morphological and physiological development of shoots and plants from different explants as they apply to automation of MP.



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448
USE OF SOMATIC EMBRYOS AS SYNTHETIC SEEDS FOR REDUCING MICROPROPAGATION COSTS
Dennis Gray and M. Compton, University of Florida, CFREC, 5336 University Ave., Leesburg, FL 34748

Somatic embryogenesis is the most efficient method of clonal propagation that can be envisioned. Somatic embryos engineered to be of practical use in plant production are termed "synthetic seeds". Mature somatic embryos possess pre-formed shoot and root meristems and can be induced to germinate with minimal manipulations. Over 2,000 somatic embryos have been recovered per gram of culture material. Therefore, many plants can be produced with little manipulation when compared to conventional micropropagation. Perhaps the most immediate application of synthetic seed technology exists for crops with high per plant values that are already propagated by tissue or organ culture, such as many ornamental species. Propagation of these crops is labor-intensive. Integration of simple synthetic seed systems would dramatically reduce labor requirements, thus lowering production costs. Furthermore, substitution of synthetic seed technology for tissue and organ culture technology in the commercial micropropagation industry would allow a wider variety of crop types to be economically produced.

449
THE ENVIRONMENT UNDER WHICH THE STOCK PLANT IS GROWN INFLUENCES EXPLANT PERFORMANCE *IN VITRO*
Paul Read, Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724

Environmental factors under which the stock (mother, donor) plant has been grown, including temperature; light duration, quality, and intensity; mineral nutrition; and ambient gases can have significant impact on explant responses *in vitro*. Bulblet production in hyacinth has been influenced by mother bulb storage temperature. Shoot proliferation and rootability of microshoots of rhododendron have been modified by light intensity and light quality. Photoperiod has been demonstrated to affect tuber and callus formation on potato and dahlia. Furthermore, plant growth regulator treatments of the stock plant can strongly influence *in vitro* responses of explants taken from such plants. Implications of these latter responses will be discussed with regard to possible endogenous hormonal activity.

## 203 COLLOQUIUM 4 (Abstr.450–455) Intellectual Property Rights: Protection of Plant Materials

450
INTRODUCTION TO COLLOQUIUM ON INTELLECTUAL PROPERTY RIGHTS: PROTECTION OF PLANT MATERIALS
Allan K. Stoner, USDA-ARS, Building 003, Room 224, BARC-West, 10300 Baltimore Avenue, Beltsville, MD 20705-2350.

Historically, intellectual property protection for plants has been viewed differently than for other forms of technology; however, in recent years several factors have led to an increased motivation to protect plant materials. This, in turn, has resulted in many questions and concerns for scientists, administrators, and policy makers regarding options available for protection; impact of protection on research agendas and germplasm exchange; and ethical and social considerations. A workshop on Intellectual Property Rights: Protection of Plant Materials was held in Washington, DC, on January 26-28, 1993. This meeting was to provide invited participants the latest information on the protection of plant-derived intellectual property via patents and other means. It was also intended to review and develop policies and procedures that are publicly responsible; yet, provide incentives to assure commercialization of new inventions. The organizers and attendees agreed that a record of the workshop would be published and that special efforts should be made to communicate the results of discussions to the membership of scientific societies such as ASHS.

451
STATUS OF INTELLECTUAL PROPERTY RIGHTS PROTECTION
Robert J. Jondle, Henderson and Sturm, One Pacific Place, 1125 S. 103rd St., #330, Omaha, NE 68124-1076

The various forms of intellectual property rights are discussed and compared including utility patents, Plant Variety Protection Certificates, Breeder's Rights, and Plant Patents. Recent developments in Plant Variety Protection and Breeder's Rights are reviewed, including the recent court decision in Asgrow v. Winterboer. How an "essentially derived" variety will be defined in the new 1991 UPOV convention, and in member countries, including several examples will be discussed. Recent examples of issued utility patents will also be presented.

452
INTERNATIONAL GERMPLASM COOPERATION - CONCERNS, FUTURE
Henry L. Shands, USDA/ARS/National Program Staff, Bldg 005, BARC-W, Beltsville, MD 20705

International plant germplasm cooperation has been strongly based upon scientist to scientist cooperation in the past, most often from academic relationships. Exchanges of germplasm between scientists has been common. In the more formal system, public institutions have relied upon bilateral and multilateral government programs and upon efforts of cooperation with International Agricultural Research Centers of the CGIAR. All of these cooperation efforts have involved access to genetic resources. The IBPGR, in its new structure, the International Plant Genetic Resources Institute, will be little involved in germplasm exchanges. UNEP's Convention on Biological Diversity has legal language, when in force, may greatly affect access to genetic resources directly and though international centers even though the objective is to make them more readily available. Public sector institutions in the United States will have greater difficulty than private seed industry firms in arranging access when a cost is negotiated but perhaps easier access when training and other cooperation is acceptable. Some possible activities of cooperation in the future to gain access are discussed.

453
IMPACT OF INTELLECTUAL PROPERTY PROTECTION ON PUBLIC RESEARCH AGENDAS
Fredrick A. Bliss, Department of Pomology, University of California, Davis, CA 95616

Novel ideas and plant materials developed as a result of individual and collective investigations of biological phenomena may in some cases be protected as intellectual property. Depending on the circumstances surrounding each situation, plant patents, utility patents, plant varietal protection (PVP) and trade secrets may be used to limit unauthorized use of and to collect royalties on one's intellectual properties. In addition to these instruments, agreements over use and distribution of materials not formally protected often are requested before ideas and biological materials are exchanged. Although public-supported institutions usually promote exchange of information, these legal and informal arrangements often impact "free" exchange if they are not well understood. Ways to utilize intellectual property protection and to avoid unnecessary constraints will be discussed.

454
THE IMPACT OF INTELLECTUAL PROPERTY PROTECTION ON PRIVATE RESEARCH AGENDAS
M. Allen Stevens, Petoseed Co., Inc., 37437 State Highway 16, Woodland, CA 95695

The rulings that utility patents can be granted for plant varieties has had a profound effect on the research agendas of seed companies. Although there is confusion on utility patents, most major seed companies are concerned about how they will affect their competitive position. Strategic alliances are common; these may involve a seed company (germplasm resources) and a biotechnology company (gene constructs). Licensing agreements are frequently used to access new technologies and genes. Material transfer agreements are being used to access genes for proof of concept studies. Commercial agreements have thus far been elusive. Seed companies strongly favor revision of the Plant Variety Protection Act to conform to the 1991 International Union for the Protection of New Varieties of Plants (UPOV) Convention.

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ETHICAL AND SOCIAL ISSUES OF INTELLECTUAL PROPERTY RIGHTS PROTECTION OF PLANT MATERIALS

Edward J. Ryder, USDA-ARS, U.S. Agricultural Research Station, 1636 E. Alisal St., Salinas, CA 93905

In January 1993, a workshop on intellectual property rights as applied to plants was held. One topic of discussion was the question of ethical and social issues that may apply to the protection of plant materials. Seven issues were identified that appeared to have ethical and social implications in such protection. These were: 1) criteria for access to germplasm, 2) the effects on global biodiversity and developing nations, 3) plants as private property, 4) effects on agricultural social structures and sustainability, 5) survival of public sector research, 6) the rights of farmers to save and sell seed, and 7) the need for education of students and the public to understand the concepts of plant protection and its ramifications. Six recommendations to clarify these questions were derived. These propose: to provide education, revise the applicable laws, support public research in plant breeding, maintain the research exemption in the use of protected materials, set up an arbitration system over disputes, and consider means of compensating developing nations for use of germplasm within their borders.

In addition, the definition, applicability, and consequences of intellectual property rights protection for plants will be discussed. In particular, the impact on the public sector and public/private sector relationships will be examined.

# 204 ORAL SESSION 51 (Abstr. 456–461)
## Vegetable Crops: Seedling Establishment

456

FIELD EMERGENCE OF *SHRUNKEN-2* CORN PREDICTED BY SINGLE AND MULTIPLE VIGOR LABORATORY TESTS

Carlos A. Parera and Daniel J. Cantliffe*, University of Florida, IFAS, Horticultural Sciences Dept., P.O. Box 110690, Gainesville, FL 32611-0690

A rapid and reliable predictor of sweet corn seed field emergence is required to produce high-quality, uniform crops. Field emergence of seven *sh2* sweet corn cultivars grown at 3 geographic locations in Florida over 2 planting periods (fall and spring) was correlated with laboratory vigor tests. Factor analysis was used to separate non-collinear vigor tests for subsequent multiple regression models. The best single predictor test ($R^2$=0.93$^{***}$) was an index based on conductivity of the leachate and germination percentage after complex stressing vigor test incubated at 15°C. Leakage conductivity after 3 h soaking at 25 or 30°C ($R^2$=0.90$^{***}$), cold test in soil ($R^2$=0.90$^{***}$), mean alternate temperature stress conductivity test ($R^2$=0.88$^{***}$), standard germination test incubated at 30°C ($R^2$=0.88$^{***}$), and the index incubated at 25°C ($R^2$=0.88$^{***}$) were also good predictors of field emergence. Non-collinear tests including the towel germination test at 25°C and an alternate temperature stress conductivity test generated the highest most significant two factor predictor ($R^2$=0.89$^{***}$), and with glutamic acid decarboxylase activity (GADA) the best three factor predictor ($r^2$=0.93$^{***}$). The index of conductivity and complex stressing vigor test (ICS) proposed as a predictor of seed emergence considered two main factors affecting emergence in *sh2* sweet corn: the condition of the membrane of the seeds and potential pathogen infection.

457

LEAKAGE OF SOLUTES FROM IMBIBING SEEDS OF SUPERSWEET CORN CULTIVARS THAT DIFFER IN TOLERANCE TO LOW GERMINATION TEMPERATURES

Linda Kull* and Janice Coons, Botany Department, Eastern Illinois University, Charleston, IL 61920

Acceptance of supersweet types of corn is hindered due to reduced field emergence in cold soils. Reduced emergence is related to seed endosperm composition and imbibitional leaching of seed components. Seeds of two supersweet cultivars (Illini Gold and Honey'n'Pearl) with shrunken-2 endosperm were examined for differences in percent germination and days to 25% germination at 10, 15, and 20 C. Seed leachate from seeds imbibed at 10, 15, and 20 C was analyzed for electrical conductivity, sugars, and amino acids. Germination percentages were higher for 'Illini Gold' than for 'Honey'n'Pearl' at all temperatures, and higher at 20 than 10 C for both cultivars. 'Illini Gold' germinated sooner than 'Honey'n'Pearl' at all temperatures. Electrical conductivity was higher for 'Honey'n'Pearl' than 'Illini Gold', and higher at 20 than 10 C for both cultivars. At all temperatures, sugars and amino acids in seed leachate were higher for 'Honey'n'Pearl' that for 'Illini Gold', but no significant temperature effects were observed. Imbibitional leakage of ions, sugars, and amino acids was more dependent upon cultivar than temperature.

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MATRICONDITIONING AND DRYING OF SUPERSWEET CORN TO IMPROVE STAND ESTABLISHMENT

Anwar A. Khan, Wlodzimierz Ptasznik and Janusz Prusinski, New York State Agricultural Experiment Station, Cornell University, Geneva, NY 14456-0462

Effects of preplant conditioning of supersweet corn ('GSS 3368' and 'Challenger') seeds and subsequent drying on the quality and performance of seeds were studied. Matriconditioning with moist Micro-Cel E (MC) was superior to matriconditioning with moist Vermiculite #5 and Celite 400 or osmoconditioning with -1.2MPa polyethylene glycol solution at 15°C. A 1d conditioning (seed: carrier: water= 5:1:7) of 'GS 3368' and 'Challenger' sweet corn with MC improved the seed quality, as shown by reduced electrolyte leakage; reduced the time to 50% of final emergence at 10/20°C (12/12h) in a peat-lite mix by 1 to 2d; and increased the shoot wt by 70-90%, 10 to 12d after planting. Various drying protocols were used to reduce the high water content (49% w.b.) in the 1d conditioned 'Challenger' seed to 14% (w.b.). At 25°C and 30% RH, conditioned seeds needed 24h to dry to 14% water content at an air flow velocity of 0.02m/s and only 7.5h at 1.4m/s. At 35°C and 30% RH, the time of drying was reduced to 16 and 5h at 0.02m/s and 1.4m/s air velocities, respectively. At 45°C and 30% RH, seeds were dried within 5h at 0.02m/s air velocity and within 3.5h at 1.4m/s. Benefits to seeds acquired through conditioning was retained maximally by drying at 35°C, 30% RH and 1.4 m/s air velocity.

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UV COLOR SORTING TO IMPROVE *BRASSICA* GERMINATION

A.G. Taylor*[1], D.B. Churchill[2] and S.S. Lee[1], [1]Dept. Horticultural Sciences, NYSAES, Cornell Univ., Geneva, NY 14456 and [2]USDA-ARS, NFSPRC, Corvallis, OR, 97331

The purpose of color sorting by fluorescence was to upgrade seed quality by removal of fluorescent coatings that were attributed to sinapine leakage from nonviable seeds. Nine seed lots (three seed lots each of broccoli, cabbage and cauliflower) were custom coated. Seed samples were pretreated prior to coating with or without 1.0% NaOCl for 10 minutes to enhance leakage. Fluorescence, as measured by fiber optic spectrometry, was expressed from 400 to 560 nm with peak emission being from 430 to 450 nm. A UV color sorter was employed to separate fluorescent (reject) from non-fluorescent (accept) coatings. The percent non-fluorescent coatings (averaged over seed lot and NaOCl pre-treatment) before and after sorting was 89.5 and 95.9, respectively. There was a six percent loss of non-fluorescent coatings after sorting (averaged over all treatments). An increase in the percent germination was recorded in 8 of the 9 seedlots following color sorting and the greatest improvement was obtained with seed lots of medium quality. The germination of three medium quality lots was increased from 10 to 15 percentage points. The average increase in germination with or without NaOCl pre-treatment was 8.2 and 5.5 percentage points, respectively. In conclusion, the combination of coating technology with seed conditioning by UV color sorting was effective in improving *Brassica* seed performance.

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THERMOINHIBITION IN SPINACH SEEDS

Daniel I. Leskovar* and Jose R. Santos, Texas Agricultural Experiment Station, Texas A&M University, Uvalde, TX 78801, Helen Belefant-Miller, USDA, ARS, Stillwater, OK 74075.

Spinach (*Spinacia oleracea*) seed germination inhibition was examined at various temperature regimes. Inhibition occurred at higher than optimum (22C) constant temperature. At 30C, germination ranged from 10 to 40%, and was totally suppressed at 35C. Thermoinhibition at constant 30C was overcome by alternating 30/15C (12/12 h), resulting in higher percentage germination than 35/15C, 35/20C and 35/25C. Germination of whole, slit-pericarp, and pericarpless seeds incubated at 30C indicated that the pericarp imposed physical restriction and chemical inhibition on embryo growth. The ABA content of the pericarp was highest for cv 'Cascade'; however, excised 'Cascade' embryos imbibed with exogenous ABA, at a similar level as the endogenous pericarp concentration, had normal germination at 30C. Genotypes exhibited differential sensitivity to supraoptimal temperatures with 'Ark 88-354' < 'Fall Green' < 'ACX 5044' < 'Cascade'.



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EFFECT OF PLANT DENSITY AND NAA ON BUTTERNUT SQUASH YIELD

Aly M. Ibrahim*, Mohammed A. Majeed and Abdul-Rhman A. Al-Rabiah, National Agriculture and Water Research Center, P.O. Box 17285, Riyadh 11484, Saudi Arabia.

Butternut squash is a newly introduced crop in Saudi Arabia and is gaining very much popularity.

An experiment to evaluate the productivity of butternut squash using different plant spacings and trailed vs untrailed plants was conducted in tunnel greenhouse.

Results showed that trailed plants produced 100% more yield than the untrailed plants with better quality and uniformity in size. Among spacings, the plants in 120 cm produced 82% higher yield/plant than the plants in 40 and 80 cm. NAA increased yield by 14%. NAA treated or untreated trailed fruits had no seeds as compared to the untrailed fruits which did produce small amount of seeds.

## 205 ORAL SESSION 52 (Abstr. 462–469)
## Small Fruit: Culture and Management

462

EFFECT OF LIGHT EXCLUSION ON THE PIGMENT DEVELOPMENT, SUGAR, TITRATABLE ACIDITY, AND TOTAL PHENOLICS IN THE CLUSTERS OF 27 GRAPE CULTIVARS.

M. Ahmedullah*, Department of Horticulture and Landscape Architecture, Washington State University, Pullman, WA 99164-6414

The clusters of 27 grape cultivars representing red, blue and black colors were bagged before veraison to exclude light. The unbagged clusters close to the bagged ones served as control. Temperature inside the bag was monitored. The clusters were harvested at commercial maturity and analyzed for quality parameters, anthocyanins, caffeoyl tartarate and total phenolics. The clusters of 15 cultivars showed a visible reduction in color by light exclusion and 12 developed color without light. There were differences in the quality parameters and total phenolics between bagged and unbagged cultivars. The possible relationship of phytochrome in the initiation of pigment development is discussed.

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CANE GIRDLING AS A MEANS TO IMPROVE EASTERN SEEDLESS TABLE GRAPE QUALITY

Henry M. Bartholomew,* and Garth A. Cahoon, OARDC Horticulture Department, 102 Gourley Hall, Wooster, OH 44691

Seedless table grapes are of increasing interest to fruit growers in the Eastern U.S. The flavor of many cultivars is excellent, but fruit quality, from an appearance standpoint, needs improvement to be competitive with California grapes. This paper will summarize results from a two year study of cane girdling Einset and Vanessa cultivars. Cane girdling was applied as whole vine treatments at pre-bloom, shatter, veraison, double girdle at both shatter and veraison, and control. The experiment was replicated on both single and double curtain training systems.

Cluster length, cluster weight, berry weight, berries per cluster were all improved with cane girdling at shatter and double girdling. Juice quality was minimally affected by the successful treatments. Vine vigor when measured as pruning weights were not affected. Grape cluster and berry size was better on the double curtain training system.

464

ONE-SIDED SHIFT-TRELLISING FACILITATES HARVEST AND REDUCES SUNSCALD (ULTRA VIOLET RADIATION INJURY) IN BLACKBERRIES

Herbert D. Stiles*, Virginia Tech Southern Piedmont Agricultural Experiment Station, P.O. Box 448, Blackstone, VA 23824.

Nearly all berries were isolated on one side of the row, and sunscald was reduced to 6% (from 47% on vertically trained canes), by "post-bloom" shifting of blackberry floricanes from a horizontal pre-bloom position to a west-facing, slanted (20° from vertical) configuration. This was made possible by our specially designed, single-sided shift-trellis (SSST).

465

PLANT SPACING EFFECTS ON YIELD AND FRUIT SIZE OF HIGHBUSH BLUEBERRIES

James N. Moore*, Maurus V. Brown, and Bruce P. Bordelon, 316 Plant Science Building, University of Arkansas, Fayetteville, AR 72701

The influence of in-row plant spacing on highbush blueberry yield and fruit size was studied on two cvs., 'Blueray' (erect growing) and 'Bluecrop' (spreading). Plants of both cvs. spaced at 0.61m in-row significantly outyielded plants at wider spacings (0.92, 1.22m) in each of the five harvest years when based on per hectare yields. On a per plant basis, however, plants spaced at 1.22m outyielded closer spaced plants in the last two harvest years of the experiment, indicating that interplant competition was reducing per plant yields on close spaced plants as plants grew larger. Over the 5-year harvest period, plots with 0.61m plant spacing produced a cumulative total yield increase of 17239 kg/ha more than plots with the conventional spacing of 1.22m. There were no effects of plant spacing on fruit size in the experiment.

466

SURVEY AND ECONOMIC ANALYSIS OF MECHANICAL RAISIN HARVESTING SYSTEMS

Greg T. Berg* and R. Keith Striegler, Viticulture and Enology Research Center, CSU-Fresno, Fresno, CA 93740-0089

The harvest and production of natural Thompson Seedless raisins traditionally has been a very labor intensive process. Current practices require significant labor inputs for harvest, turning, rolling, and retrieval of raisins. A disruption of labor supply during the harvest and drying period would be detrimental for raisin growers.

During the 1992 raisin harvest, a small-scale demonstration trial was conducted in the CSU Fresno campus vineyard. Two mechanical raisin harvesting systems were utilized in a side-by-side comparison with the traditional method of raisin harvesting. Each system was used to harvest a six-row block in two vineyard locations. Data were collected regarding the procedures, costs of operation, and labor requirements for each system from pre-harvest practices to the boxed, farm-level product.

When the actual time and motion data collected from our 1992 research were adjusted to reflect industry average vineyard situations (i.e., yields of 5.6 metric tons/hectare and 402m row lengths), the mechanical harvest systems exhibited significant economic and labor-saving advantages over the traditional hand raisin production system.

467

EFFECT OF POLYETHYLENE MULCH COLOR ON THE FRUITING RESPONSE OF STRAWBERRY

Earl E. Albregts* and C. K. Chandler, Univ. of Florida, Agriculture Research and Education Center, 13138 Lewis Gallagher Rd., Dover, FL 33527

Eight colors of polyethylene mulch were evaluated in the strawberry (Fragaria x ananassa, Duch.) production field. Fruit production by March 1 was increased during 3 seasons by yellow and 2 seasons by white colored mulches compared to the black mulch. Average fruit weight, number of fruit per plant, and percent marketable fruit affected fruit yield depending on the season. Total fruit yield was reduced with some of the colored mulches during two seasons. The soil temperature of the plant beds was warmest throughout the season with the black mulched beds and coldest with the white and yellow mulched beds.

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468
MULCH TYPE EFFECTS IN ANNUAL HILL STRAWBERRY PLASTICULTURE SYSTEMS
David G. Himelrick* and W.A. Dozier Jr., Department of Horticulture, Auburn University, Auburn, AL 36849

Fresh dug 'Chandler' and 'Selva' strawberry plants were fall planted in 1990, 1991, and 1992 on fumigated, trickle irrigated, raised beds covered with either six or eight different plastic mulches plus a bare ground (BG) treatment. Plastic mulch treatments included clear (CLR), black (BLK), laminated white on black (W/B), laminated black on white (B/W), IRT-76 (IRT), AL-OR brown (ALOR), silver (SIL), and red (RED).

The highest yields for 'Chandler' in 1990 were obtained on IRT followed by CLR, ALOR, B/W, BLK, W/B, and BG. The highest yields for 'Selva' were on CLR followed by BLK, ALOR, IRT, B/W, W/B, and BG. The highest yields for 'Chandler' in 1991 were on W/B followed by BLK, ALOR, IRT, B/W, CLR, and BG. In the case of 'Selva' ALOR was the top performing treatment followed by IRT, W/B, BLK, B/W, BG, and CLR. The first two years of data were inconclusive. Data from 1992 planting will be included to clarify yield, earliness, and season length effects.

469
**DRIP IRRIGATION OF MULCH 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 has recently been under study as a potential means of increasing photosynthesis in the field situation. Cahn (1989) and Novero (1991) have demonstrated that carbonated water lowers soil pH in strawberries and tomatoes, respectively. Novero showed greater uptake of zinc and increased marketable fruit yields. Currently, we are evaluating the influence of carbonated water on strawberry (*Fragaria x ananassa cv* Muir) growth using a high pH, high calcium soil and a low pH, low calcium soil in the greenhouse. Carbonated water applied to a high pH, high calcium soil significantly increased leaf, bud and open flower number, as well as greater crown and leaf dry weights.

## 206 ORAL SESSION 53 (Abstr. 470–477) Vegetable Crops: Nutrition

470
NUTRIENT CARRIERS FOR DRIP/TRICKLE FERTILIZING PEPPERS
James W. Paterson,* Rutgers University, Rutgers Research & Development Center, RR 5, Box 232, Bridgeton, NJ 08302-9499

The desirability of selected primary plant nutrient carriers ($N$-$P_2O_5$-$K_2O$) for drip/trickle fertilizing bell peppers (*Capsicum annuum* L.) on a coastal plain sandy loam soil was investigated in 1990 and 1992. Soluble dry and liquid fertilizer carriers selected in both years were urea ammonium nitrate (30-0-0), ammonium sulfate (21-0-0), potassium nitrate (14-0-46), phosphoric acid (0-54-0), ammonium polyphosphate (10-34-0), and muriate of potash (0-0-62). These materials in combinations were compared to a more expensive commercially prepared dry fertilizer (20-20-20) which was formulated from urea, mono and diammonium phosphate and potassium nitrate. Although the commercial fertilizer (20-20-20) produced significantly more early and midseason yields of No. 1 plus No. 2 peppers than one-third of the less expensive formulated grades, all treatments produced the same late and total yields of pepper in 1990. In 1992, the ammonium sulfate, ammonium polyphosphate and muriate of potash treatment produced significantly more total No. 1 plus No. 2 peppers than did the phosphoric acid and muriate of potash with either urea ammonium nitrate or ammonium sulfate; however, no treatment differences were noted in total yields of quality No. 1 peppers.

471
$CO_2$ AND TEMPERATURE INTERACTION ON STARCH AND MINERAL CONCENTRATIONS IN POTATO LEAVES
W. Cao* and T.W. Tibbitts, Dept. of Horticulture, Univ. of Wisconsin, Madison, WI 53706

Foliar concentrations of starch and nutrients (N, K, Ca, Mg, P and S) were determined in three potato (*Solanum tuberosum* L.) cvs Denali, Norland and Russet Burbank grown for 35 days under 500, 1000, 1500 and 2000 ppm $CO_2$ at each of 16 and 20C. The plants were grown in 8-liter plastic pots containing commercial peat-vermiculite mix under controlled environments with 450 $\mu$mol $m^{-2}$ $s^{-1}$ PPF for 12 h photoperiod. The average starch concentrations in three cultivars increased from 4.4% to 18.5% d.w. with increased $CO_2$ and decreased temperature. The starch concentrations were linearly related to specific leaf weight with a $R^2$ of 0.97. With or without starch correction, the concentrations of N, Ca, Mg, P and S on dry weight basis tended to decrease with elevated $CO_2$ and reduced temperature whereas the concentration of K did not change with the $CO_2$ levels and was higher at 16C than at 20C. Combined mineral concentrations of N, Ca, Mg, P and S, before or after starch correction, were negatively related to the starch concentrations up to 14%, and then changed only slightly with higher starch concentrations. These results will be discussed in terms of potential growth enhancement from $CO_2$ supplementation.

472
CROP CORRELATION AND CALIBRATION OF MEHLICH-1 SOIL TEST EXTRACTANT FOR VEGETABLES
George Hochmuth*, Ed Hanlon, Bob Hochmuth, Jerry Kidder, and Dale Hensel, Horticultural Sciences Department, 1143 Fifield Hall, University of Florida, Gainesville, FL 32611-0690

The Mehlich-1 (double-acid) soil test extractant is used widely on sandy soils in the southeastern United States. Research with eight major vegetables in Florida showed that the Mehlich-1 solution for phosphorus was correlated with crop yield and quality responses. Soils with a Mehlich-1 index for phosphorus greater than 30 $mg \cdot kg^{-1}$ required no phosphorus fertilization. Crop responses were not highly correlated with Mehlich-1 potassium index and it was difficult to predict crop response to potassium fertilization. The lack of predictive capability of the Mehlich-1 extractant for potassium raises questions over soil testing for potassium on sandy soils in Florida where potassium is mobile.

473
FERTILIZER LEVELS MAXIMIZING YIELDS AND ECONOMIC RETURNS FROM VEGETABLE AMARANTH IN THE MIDSOUTH.
J. D. Downes*, 1231 Miami St., Athens, TN 37303 and Donald J. Makus, USDA-ARS, Rt. 2, Box 144-A, Booneville, AR 72927

In an Arkansas mineral soil with pH of 5.7 and testing 59, 14, and 84 kg/ha of N, P and K, respectively, two cultivars of vegetable amaranth (Amaranthus tricolor L.), 'Hinn Choy' and 'RC 241' were grown in a fertilizer (3N x 3K x 4P) field experiment. Fertilizer P accounted for 90% of leaf fw yield variations, followed by K, 3%; and N, 2%. Multiple regression equations summarize the yield responses:

$Y_{hc} = .528 + .00658\ N + .146\ P - .0000293\ N^2 - .001537\ P^2 + .0001351\ N*P + .0001854\ P*K$, $R^2 = .964$

$Y_{rc} = .63 + .2085\ P - .001349\ P^2 + .0003497\ P*K$, $R^2 = .954$

where Y = mt/ha, N, P, K = kg/ha of N, P and K.

Fertilizer levels maximizing yields, and optimum levels under varying fertilizer cost/crop price situations were estimated using the derivatives and cost/price ratios. In RC estimated $P_{max}$ = 101 kg and estimated $P_{opt}$ = 93 kg at $1.33/kg P and $66/mt of crop.

474
SHIFTING PLANT NUTRITION PARADIGMS
C. M. Geraldson*, IFAS, University of Florida, Gulf Coast Research & Education Center, Bradenton, FL 34203

The gradient concept as a shift in nutritional paradigms is designed to establish and stabilize a nutritionally optimal ionic composition in the soil solution and thus, the potential to provide nutritional accountability. This is accomplished by synchronizing the nutrient/water input with removal. The basic components are a constant water table with a constant



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but separate source of N-K from the soil bed surface, all of which is protected by a full bed mulch. By shifting to the gradient-mulch system, Florida tomato growers more than doubled their yields and increased profitability by 40 to 60%. Conventional research efforts such as irrigation and fertilizer scheduling become irrelevant, along with measures of evapotranspiration and tensiometers; soil testing and plant tissue analyses can be de-emphasized and the many statistically designed experiments to evaluate nutrient levels have an outmoded nutritional validity. The shift of the gradient technology to a containerized concept has a maximum potential in the development of a globally sustainable production system. The failure to utilize these innovative paradigms limits the potential of nutritional research to advance beyond a level of mediocrity.

475

LIGHT AND NITROGEN LEVELS AFFECT THE AGRONOMIC PERFORMANCE OF VEGETABLE AMARANTH

D. J. Makus, USDA-ARS, Booneville, AR 72927

Three-week-old transplants of Amaranthus tricolor cultivars 'RRC 241' and 'Hinn Choy' were given split applications of supplemental N (0, 100 and 200 kg/ha). Five weeks after sowing both cvs. were exposed to 100, 70 and 50% of ambient solar radiation for nine and ten days, respectively. During shading, avg. daily photosynthetic irradiance was reduced from 11.6 to 7.7 and 5.0 KW/m$^2$, respectively. Soil, air, and leaf temperatures were reduced by shading. Plants were harvested in the seventh week. Cultivars differed in leaf number and area, yield, height, mineral uptake, and stem fresh and dry weight. Increasing shade levels decreased the dry wt. of stems, leaf blades, and plants. Shading had no effect on leaf area, plant fresh wt. or yield, but increased stem length, plant water content and leaf blade pigments. Photosynthetic fixation rates were reduced by 50% shade. Leaf blade protein and most leaf blade mineral nutrients, including nitrates, were increased by shading. Nitrogen application increased stem length, stem, leaf blade and plant fresh and dry wt., leaf blade pigments and yield.

476

WATERMELON SEEDLING GROWTH AND ROOT CALCIUM ABSORPTION AS INFLUENCED BY THE FUNGICIDES CAPTAN AND THIRAM

Aimin Liu*[1], Joyce G. Latimer[1], and Robert E. Wilkinson[2]. Dept. of Horticulture[1], Dept. of Agronomy[2], Georgia Experiment Station, University of Georgia, Griffin, GA 30223-1797

Unilateral application of $Ca^{2+}$ and $Al^{3+}$ induced curvature in roots of 'Starbrite' watermelon [Citrullus lanatus (Thumb.) Matsum and Nakai] seedlings from both untreated and commercially pretreated seeds. In untreated seeds, PCMBS inhibited root curvature by decreasing $Ca^{2+}$ and $Al^{3+}$ uptake. In pretreated seeds, PCMBS only inhibited $Ca^{2+}$-induced root curvature. Captan and thiram inhibited $Ca^{2+}$- or $Al^{3+}$-induced root curvature. Captan showed the greatest inhibition of $Ca^{2+}$ uptake at 100 mg/liter, whereas thiram was most effective at 0.01 mg/liter. The effects of captan and thiram were statistically additive. Thiram appeared to show a similar mode of action to PCMBS in affecting $Ca^{2+}$ uptake. DDT reversed the inhibitory effect of thiram, but not that of captan.

Acid soil (pH 4.6) reduced number of leaves, leaf, stem, shoot and whole plant dry weight, and stem length. Pretreated seeds produced greater root dry weight and root:shoot ratio in acid soil than did untreated seeds. Fungicides may have reduced $Al^{3+}$ toxicity by inhibiting $Al^{3+}$ uptake in acid soil.

477

GENETIC ADAPTATION OF VEGETABLE CULTIVARS TO NUTRIENT-DEFICIENT SOILS.

John E. Bowen* and Patricia Macomber, Plant Molecular Physiology Dept., Beaumont Agric. Research Center, Univ. of Hawaii, Hilo, Hawaii 96720.

Cultivars of many vegetable crops; e.g., tomato and Chinese cabbage, differ genotypically in rates of uptake and accumulation of various essential nutrients. Indeed, selection of a nutrient-inefficient cultivar can cause crop failure. The physiology and kinetics of some of these differences have been studied. Excised tomato roots (Lycopersicon esculentum L.) cv Kewalo absorbed $Zn^{2+}$ and $Cu^{2+}$ much more rapidly than did cv Sel 7625-2. Uptake of each cation was competitively and reciprocally inhibited by the other. Root apices from the two tomato cvs did not differ in their affinities for $Zn^{2+}$ and $Cu^{2+}$, however. Vmax values for $Zn^{2+}$ and $Cu^{2+}$ uptake in cv Kewalo roots were three-fold greater than those for cv Sel 7625-2.

Chinese cabbage cvs Nozomi and Aichi have significantly higher requirements for B and K, respectively, than do 11 other cvs. Cv WR Green 60 requires more P and Ca but cv Nagaoka 50 has a significantly lower Mg requirement than the other cvs tested. No significant differences occurred among the 12 cvs with regard to their Zn, Mn and Cu requirements.

## 207 ORAL SESSION 54 (Abstr. 478–482)
## Cross-commodity: Chilling Stress

478

LIPID CHANGES IN BELL PEPPER FRUIT DURING CHILLING AND REWARMING

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

Lipid composition and pigment content in bell pepper fruit that were freshly harvested, chilled 2 weeks at 2C (CH), or chilled then rewarmed to 20C for 4 days (RW), were determined. There was slight to moderate loss of glycerolipids during chilling, with much greater losses after rewarming. Loss of galactolipid (GL) exceeded that of phospholipid (PL). The ratio of the GL, MGDG:DGDG, did not change in CH and RW fruit, and there was no loss of chlorophyll or change in the Chl a:b ratio, but neutral carotenes declined ca 30 % after rewarming. Only small changes in total membrane sterols (TMS) were noted in CH and RW fruit, but major changes in sterol glycosylation and esterification occurred. The stigmasterol:sitosterol ratio increased during chilling and after rewarming. Due to PL loss, the ratios of TMS and cerebrosides to PL increased sharply in RW fruit. The ratio of 18:2 to 18:3 declined with chilling and with rewarming in all acyl lipids, but total unsaturation increased only in GL. These results indicate that most membrane damage occurs after rewarming and that the chloroplasts are especially chilling sensitive.

479

HIGH-PRESSURE GAS ATMOSPHERES AND ANESTHETICS ALTER THE CHILLING SENSITIVITY OF PLANTS

Mikal E. Saltveit, Jr., Mann Laboratory, Department of Vegetable Crops, University of California, Davis, CA 95616-8631

Changes in membrane fluidity at low, non-freezing temperatures are thought to be involved in chilling injury - a physiological disorder of many economically important plants, e.g. banana, cucumber, maize, rice, and tomato. Atmospheres of 12 MPa He or $N_2$ increased the rate of ion leakage from excised cucumber cotyledon discs, cucumber hypocotyl segments and tomato pericarp discs and also increased the threshold temperature at which chilling occurred by 2° to 6°C. Exposure to vapors of the mammalian anesthetics halothane and methoxyflurane reduced chilling injury in the same tissues. The relative effectiveness of the two anesthetics in reducing chilling injury was similar to their relative effectiveness in inducing anesthesia in animals and their relative lipid solubilities. The response of the tissues to halothane and methoxyflurane, which are known to increase membrane fluidity, and to high pressures, which are known to reduce membrane fluidity, are consistent with the hypothesis that a cold-induced phase transition of membranes could be responsible for chilling injury.

480

CHILLING INJURY ON GRAPEFRUIT IS RELATED TO GAS PERMEABILITY OF THE PEEL

Roy E. McDonald* and T. Gregory McCollum, USDA, ARS, U.S. Horticultural Research Laboratory, 2120 Camden Road, Orlando, FL 32803

Differences in chilling injury (CI) susceptibility of 'Marsh' grapefruit (Citrus paradisi Macf.) from interior and exterior tree canopy positions were used to determine the effects of temperature conditioning (7 days at 21C), application of squalene (10% in hexane), and high oxygen (42%) atmospheres on CI development during low temperature storage. Chilling injury was significantly lower on interior tree canopy, temperature conditioned, squalene treated, and fruit stored in ambient oxygen atmospheres compared



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with exterior tree canopy, nontemperature conditioned, and fruit stored in high oxygen atmospheres. Greater air flux was observed through exterior canopy compared with interior canopy fruit, and through the sun-exposed surface compared with the shaded surface of exterior canopy fruit. Rate of oxygen diffusion through the peel of exterior canopy was greater than interior canopy fruit, and through the sun-exposed surface compared with the shaded surface of exterior canopy fruit. Permeability of grapefruit peel to air and oxygen may influence the expression of CI.

481

SUSCEPTIBILITY OF BELL PEPPER MICROSOMES TO PEROXIDATIVE CHALLENGE AT DIFFERENT TEMPERATURES

Darlene M. Cowart*, Marilyn C. Erickson, and Robert L. Shewfelt, Food Safety and Quality Enhancement Laboratory, Georgia Agricultural Experiment Station, University of Georgia, Griffin, Georgia 30223

Temperature stress resulting in membrane-associated disorders has been linked to lipid peroxidation through free radicals, but the susceptibility of membrane lipids in microsomal fractions to chilling stress has not been clearly delineated. Microsomal membranes isolated from bell peppers were subjected to five oxidative conditions (iron-ascorbate, xanthine oxidase, cumene hydroperoxide, and lipoxygenase (LOX) with and without $PLA_2$) at three temperatures (6, 21, and 37C) and measured at 30 min. intervals during a 2 hour incubation to determine the effect of temperature on peroxidation as measured by TBA-RS. During the first 30 min., the rate of peroxidation was greater at 6C than at 21C or 37C in four of the five systems tested. Preincubation with $PLA_2$ followed by addition of LOX produced the highest amount of peroxidative products when compared with all other systems demonstrating the importance of free fatty acids in lipoxygenase-catalyzed peroxidation. The results demonstrate an increased susceptibility of microsomal membranes isolated from a chilling-susceptible fruit to peroxidative challenge at chilling temperatures than at higher temperatures.

482

CHARACTERIZATION OF CHILLING-REGULATED PROTEINS IN FLORAL BUDS OF BLUEBERRY

Mubarack M. Muthalif and Lisa J. Rowland*, USDA/ARS, Fruit Lab, Bldg. 004, Beltsville Agricultural Research Center-West, Beltsville, MD 20705

Attempts have been made to identify changes in gene expression in dormant buds of woody plants in response to chilling unit accumulation. In our earlier analyses of total proteins from blueberry floral buds, we found that the concentration of at least three polypeptides varied in response to chilling. More recently, soluble proteins have been extracted from floral buds of the high-chilling variety 'Bluecrop' and the low-chilling variety 'Tifblue'. This extraction procedure was found to enrich for the chilling-regulated proteins, which include three major polypeptides of 72, 65, and 17 kilodaltons and several minor polypeptides. Furthermore, the chilling-induced polypeptides were found to be extremely thermal stable, resisting denaturation even after boiling for more than 15 minutes. Cold hardiness levels were assessed for dormant buds of 'Bluecrop' and 'Tifblue' after 0, 300, 600, 900, and 1200 chilling units. A positive correlation was observed between the level of cold hardiness and the levels of chilling-induced proteins suggesting a role for these proteins in the development of cold hardiness.

## 208 ORAL SESSION 55 (Abstr. 483–490)
## Floriculture: Growth and Development

483

EFFECT OF SUPPLEMENTAL AND PHOTOPERIODIC LIGHTING ON FLOWERING OF SATIN FLOWER

Robert G. Anderson* and Wenwei Jia, Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington KY 40546

Satin flower (*Clarkia amoena* ssp. *whitneyi*; syn. *Godetia whitneyi*) is a cool temperature plant grown as a cutflower in Japan, Europe and California with great market potential for Christmas and Valentine's Day markets. Sequential crops of 4-week-old plugs of 'Grace Rose Pink,' 'Grace Salmon,' 'Grace Red' and 'Satin White' were planted 24 Sept, 15 Oct and 5 Nov 1993. Plants were placed immediately in the following supplemental and photoperiodic lighting treatments: ambient light; incandescent light 1800 to 2400 HR, 8 $\mu$mol $s^{-1}m^{-2}$; HID light 1800 to 2400 HR, 40 $\mu$mol $s^{-1}m^{-2}$ HPS; HID light 1800 to 2400 HR, 150 $\mu$mol $s^{-1}m^{-2}$ HPS. The node number and days to flower for satin flower plants in the ambient light treatment were significantly different from lighting treatments in each crop. Node number and days to flower were similar in the three lighting treatments for the first crop. Node number was similar for the lighting treatments for the second and third crop but days to flower was significantly different between the lighting treatments.

484

ACCELERATING GROWTH OF GERANIUMS IN PLUGS WITH LIGHT AND CARBON DIOXIDE.

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

Seeds of *Pelargonium* × *hortorum* 'Scarlet Elite' were germinated in #406 plug trays under fluorescent lights using an irradiance of 100 $\mu$mol $s^{-1}$ $m^{-2}$ and 18 hr photoperiod and ambient $CO_2$. Upon emergence seedlings were exposed to irradiances of 100, 225 or 350 $\mu$mol $s^{-1}$ $m^{-2}$ and $CO_2$ levels of 500, 1000, or 1500 $\mu$l $l^{-1}$ for 7 to 35 days after which they were transplanted in 10 cm pots and grown to flower under greenhouse conditions. Seedling height decreased as irradiance increased, and increased as $CO_2$ increased. Seedling quality increased with increasing irradiance and $CO_2$. Elevated $CO_2$ at any irradiance during the seedling stage decreased days to flower during the growing on stage.

485

GROWTH AND DEVELOPMENT OF *CATHARANTHUS ROSEUS* UNDER VARIOUS ENVIRONMENTAL CONDITIONS

Margaret Pinchbeck* and Richard J. McAvoy, Department of Plant Science, University of Connecticut, Storrs, CT 06269-4067

In recent years, *Catharanthus roseus* has become a popular bedding plant, but at present there is little cultural information available for growers. This study examines the effects of four different temperature regimes and two light levels on three cultivars of *Catharanthus*. Average daily temperature regimes ranged from 15.3°C to 27.3°C; light intensities were 125 $\mu$mol$m^{-2}s^{-1}$ and 250 $\mu$mol $m^{-2}s^{-1}$. Plants were harvested as each successive pair of true leaves reached 1.5 cm in length, from the first true leaf stage until flowering. Measurements included internode length, leaf length, leaf area, dry weight of stem and leaves, and number and length of shoots. The plants grown at the lowest temperature regime took four times as long to flower as those grown at the highest temperature regime. Plants grown at the coolest temperature also exhibited chlorosis, stunting, and unusual flower formation. Information obtained from this study should assist growers in determining their planting schedule and the optimum greenhouse temperature for desired plant habit.

486

VARIATIONS IN BRANCHING OF CHRYSANTHEMUM CULTIVARS AS INFLUENCED BY SEASON, TEMPERATURE, AND IRRADIANCE.

Richard Kent Schoellhorn', James E. Barrett and Terril A. Nell, Department of Environmental Horticulture, University of Florida, Gainesville, FL. 32605.

Effects of irradiance and temperature on bud break and elongation in chrysanthemum (*Dendranthema grandiflora* x Ramat.) were studied. *Expt. 1* - 2 growth chambers were maintained at air temperatures of 25C and 30C and within each chamber root-zone temperatures were maintained in relationship to air temperature (+5C, 0C, -5C). At 15C/20C and 30C/25C root-zone/air temperatures, lateral number was reduced up to 50%. Variation in response was seen between cultivars 'Tara' and 'Limelight'. *Expt. 2* - A study of the interaction of temperature, irradiance and cultivar on lateral number showed increasing irradiance from 400 to 1400$\mu$mol $m^{-2}s^{-1}$ increased lateral numbers by up to 40% depending on cultivar. Cultivars 'Limelight', 'Tara' and 'Improved Mefo' were used. Temperature had no effect on lateral number.



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CARBOHYDRATE COMPOSITION OF PLANT ORGANS AND LEAF DIURNAL CARBOHYDRATE FLUCTUATION IN SNAPDRAGON

Ricardo Campos* and William B. Miller, Department of Horticulture, Clemson University, Clemson, SC 29634-0375.

The objective of this work was to determine the carbohydrate composition of snapdragon (*Anthirrinum majus* L.) organs, and the diurnal carbohydrate fluctuation in leaves. Particular interest was in mannitol, a polyol that occurs in snapdragon. Mannitol was present in all organs; its concentration was highest in shoot tips (68 mg/g dw) and lowest in roots (12 mg/g dw). Mature flowers had the highest soluble carbohydrate concentration (328 mg/g dw) and roots the least (45 mg/g dw). Starch concentration varied from 15 to 60 mg/g dw. An undetermined sugar was found in all organs. In the diurnal study, conducted in the greenhouse, the undetermined sugar had the highest concentration at midnight and the lowest at noon. In vegetative plants, total soluble carbohydrates and starch were highest at 9 and 6 pm, respectively; whereas in reproductive plants, they were highest at midnight and 9 pm, respectively.

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STEM ELONGATION IN 'CARA MIA' ROSES

Francisco Bravo-Plasencia* and J. Heinrich Lieth, Environmental Horticulture, University of California, Davis, CA 95616-8587.

Stem length of cut flower roses is one of the primary determinants of the sales price. Thus knowledge of the process of shoot elongation is useful in optimization of rose production. In this study shoot elongation was investigated by continuously logging 'Cara Mia' rose shoot length using linear displacement position sensors (LDPS). Under natural conditions, elongation was found to occur mainly at night. The objective of this study was to investigate the role of environmental factors on rose stem elongation and to determine whether the process was related to an endogenous circadian rhythm or the absence of light. Measurements were made under various photoperiodic conditions (0, 8, 10, 12 and 24 hours night) and various temperature regimes. Under alternating light/dark regimes, regardless of photoperiod, shoot elongation rates follow a cyclical pattern with maximum values during dark periods and lower rates during periods of light. The elongation rate declined abruptly with the beginning of the light, suggesting that phytochrome activity might be responsible for this cessation of elongation. Under continuous light and constant temperature, the cyclical behavior was also observed, although the amplitude of the rhythm was smaller than under continuous light.

489

A FORCING PROGRAM FOR ISRAELI-GROWN LEUCOJUM AESTIVUM AS POTTED PLANTS

A.A. De Hertogh, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Over 3 years, greenhouse and phytotron trials were conducted using Israeli-grown Leucojum aestivum. The objective was to evaluate the potential of this bulb as a potted plant for North American forcing. It was found that bulb sizes of 12/14, 14/16, and 16/up cm (in circumference) produced quality plants. Bulbs of 10/12 cm had reduced number of florets per floral stalk. The optimal cold requirement was 15-19 weeks. The major physiological disorder associated with forcing was flower abortion. Phytotron studies showed that this occurred readily at 30/26 C (Day/Night temperatures) and was minimal at 18/14 C. When >12 cm bulbs were properly programmed and forced in the greenhouse, they produced plants that were 25-35 cm tall at flowering, with 1-2 floral stalks and 4-6 florets per stalk. No plant growth retardants are required for forcing this bulb as a 15 cm diameter potted plant.

490

CHARACTERIZATION OF THREE SOLUBLE INVERTASES FROM *LILIUM LONGIFLORUM* FLOWER BUDS

William B. Miller and Anil P. Ranwala*, Department of Horticulture, Clemson University, Clemson, SC 29634-0375

Three soluble invertases (EC 3.2.1.26) previously identified in developing flower buds of *Lilium longiflorum* Thunb (HortSci. 25:1076, 1990) have been further investigated. These enzymes are fully separable on DEAE-Sephacel and differ substantially in enzymological properties. Each enzyme was further purified by consecutive use of Sephacryl S-200 gel filtration, Con A Sepharose affinity chromatography and Phenyl-Agarose hydrophobic interaction chromatography. This produced 135, 189 and 202 fold purification of invertase I, II and III, respectively. Each was an acid invertase showing pH optima between 4.0 and 5.0. The molecular weight of each invertase was estimated to be 75,000 Da by gel filtration. Invertase I, II and III showed temperature optimum at 40, 50 and 45°C, respectively. A temperature stability study revealed that Invertase III was the most stable followed by II and I. Invertase I, II and III had Km values of 1.0, 6.4 and 6.6 mM for sucrose, respectively. Invertase II and III had lower affinity to raffinose and stachyose than Invertase I. All three invertases were completely inhibited by $Hg^{2+}$ and $Ag^{+}$ ions at 1.7 mM concentration. At this concentration $Cu^{2+}$ inhibited 45% of activity of Invertase I, but only 30% of activity of Invertase II and III.

## 210 ORAL SESSION 56 (Abstr. 491–498) Vegetable Crops: New Crops

491

LETTUCE FOR PROCESSING IN LATIN AMERICA: A *McGROWING* PROBLEM FOR THE FAST FOOD INDUSTRIES

Dennis R. Decoteau* and Margaret J. McMahon, Department of Horticulture, Clemson University, Clemson, SC 29634-0375

Latin America is targeted as one of the most rapidly growing areas for expansion for McDonald's International. For example, McDonald's opened its first store in Mexico in 1985 and now has over 50 stores in that country. McDonald's is projecting to have over 100 stores in Mexico by the year 2000. Producing vegetable crops in the same country as a store is desirable to reduce shipping problems and to enhance vegetable production within the country. Problems with lettuce in Latin America include field production (poor growth and yields) and postharvest processing and handling (short shelf life). Beginning in 1992, field studies in cooperation with McDonald's International and Asgrow Seed Company were established in three field sites in Mexico and one site in Panama to determine seasonal uses of varieties (Mexico and Panama) and sites (Mexico) in order to provide quality year round production of lettuce for processing. Results suggest that varieties acceptable for trade in fresh market may not have desirable characteristics during processing (color and cut) and storage (shelf life and odor). In addition, the introduction of new varieties may be needed for year-round production.

492

DEVELOPING A SMALL-SCALE, LOW-INPUT CULTURAL SYSTEM FOR ELEPHANT GARLIC, A SPECIALTY CROP

Jeanine M. Davis*, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695

Elephant garlic (*Allium ampeloprasum* L.), which is not a true garlic, produces large bulbs with mild-flavored cloves. It is a high-priced specialty vegetable which is sold as individual bulbs or in multi-bulb decorative braids. The crop is of interest to small-scale growers because it is planted in the fall and harvested in mid-June, making it suitable for use in a multi-crop production system. Since 1989 studies have been conducted to develop a small-scale, low-input cultural system for elephant garlic. Organic versus synthetic fertilization, planting stock clove size, planting date, nitrogen rate, mulches, and multi-row plantings have been examined. Cloves have not been planted in the same field twice to avoid any soil-borne pest problems. There have been no diseases or insects and weeds have been managed with shallow cultivation. High yields of large, high-quality bulbs have been obtained by planting stock cloves greater than 20 g in mid-October and spacing them 20 cm apart in the row. A total of 140 kg N per hectare has been applied in three split-applications. Yields have averaged over 50 kg per 100 linear meters of row. Bulbs are cured by air-drying for six weeks.

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493

## WITLOOF CHICORY EVALUATIONS IN TENNESSEE

Jomo MacDermott*, D. L. Coffey, C. A. Mullins and R. A. Straw, Department of Plant & Soil Science, University of Tennessee, Knoxville, TN 37901-1071.

Production of witloof chicory (Cichorium intybus) roots for chicons or for inulin is typically a northern U. S. or European enterprise. Although chicons (Belgian endive) command a high market price, nearly all are imported from Europe. If appropriate cultivars and optimum summer growing conditions can be identified, Tennessee's mild winters may permit relatively low cost forcing techniques. Studies with these objectives were initiated in 1992 at two locations using six cultivars, two planting dates and two within row plant densities. Root yields varied from 13 to 40 $Mg \cdot ha^{-1}$ between locations and among cultivars. Incidence of bolting was greater than 50% for the earliest maturing cultivar, 'Daliva', but less than 5% for the late maturing cultivar, 'Rinof', at the warmer experimental site (Knoxville, elev. 251m). No bolting of any cultivar occurred at the cooler experimental site (Crossville, elev. 549m). Data on yield and quality of forced chicons and nitrate content of edible leaf tissue will be presented.

494

## IMPACT OF PLANTING METHOD AND SEED COLOR ON ROOT DEVELOPMENT OF JICAMA (Pachyrizus erosus (L) Urban).

Maria V. Fernandez*, Warid A. Warid, Juan M. Loaiza and Jaime J. Martínez, University of Sonora, DAG, Hermosillo, Sonora, México.

Direct seeding and transplanting were implemented on April 3, 1991. Plants aged 20 to 45 weeks were monthly sampled. Fresh and dry weight of root, diameter, length, and root type were recorded. Fresh and dry weight of root were significantly affected only by plant age. The increase occurred at the age of 39 up to 45 weeks. This period coincided with a daylength of 10 hours. Roots of 45-week-old plants had the maximun fresh weight, 187.7 g and dry weight, 26.7 g. The interaction between planting method and plant age had significantly affected root diameter. It averaged 17.7 cm in directly seeded, 45-week old plants. The incidence of forking was significantly affected by the interaction among planting method, plant age, and root type. The least occurrence of forked roots was in directly-seeded plants aged 22 to 39 weeks. Three colors: green, brown, and brownish-green of commercial seeds were recognized. Root characters of mature plants grown from transplants were studied. Brownish-green seeds produced plants having greater and thicker roots. Average fresh and dry weight was 202 and 25 g, respectively. Root diameter averaged 12.9 cm.

495

## VARIATION IN RESPONSES OF FOUR JAPANESE RADISH (*RAPHANUS SATIVUS* L.) VARIETIES TO VERNALIZATION TREATMENT.

Gerard Engelen-Eigles* and John E. Erwin. Department of Horticultural Science, University of Minnesota, St. Paul, Minnesota 55108.

Low temperature promotion of flower induction was studied on 4 Japanese radish cultivars: 'Early 40 days', 'Chinese Radish Jumbo Scarlet', 'Everest' and 'Minowase Early Long White'. Germinated radish seed were vernalized in a petri dish at 6C (inductive) or 18C (non-inductive). Photoperiod was maintained at 16hr using a mixture of fluorescent and incandescent lamps (75:25% total wattage). Japanese radish is classified as a cold promoted long day plant. Cultivars were vernalized for 5, 10, 15, 20, 25 or 30 days. Data were collected on node number and days to anthesis. Node number and days to anthesis decreased on all cultivars after a 20 day vernalization treatment. Node number and days to anthesis decreased on 'Early 40 days' and 'Everest' when they were vernalized for only 5 days. 'Chinese Radish Jumbo Scarlet' did not flower under non-inducing temperatures and long days even after 30 days which suggested that this cultivar was a cold obligate (requiring) variety. 'Early 40 days', 'Everest', and 'Minowase Early Long White' flowered under non-inductive temperatures and long days implying that these cultivars exhibit a facultative rather than obligate vernalization response.

496

## PIGEONPEA: A POTENTIAL NEW CROP FOR VIRGINIA

H. L. Bhardwaj*, M. Rangappa, and A. I. Mohamed. Virginia State University, Petersburg, VA 23806; and S.C. Phatak, University of Georgia, Tifton, GA 31793.

Six experimental pigeonpea (Cajanus cajan (L.) Millsp.) lines were evaluated during 1992 for their agronomic performance at Petersburg, Virginia under the New Crop Development Program of Virginia State University. The germination and stand establishment of indeterminate lines was poor due to low seed quality. The final seed yield varied from 349 to 2042 kg/ha with determinate types yielding significantly higher than indeterminate types. The experimental line GA#2 produced the highest yield. The protein content in mature seeds, harvested 175 days after planting (DAP), varied from 17.0 to 18.5 percent whereas the oil content varied from 1.7 to 2.3 percent. The seed yield was positively correlated with harvest index, seeds/pod, and seed weight. At 130 DAP, the 3 determinate lines yielded more than 10 metric tons of green beans per hectare (70 percent moisture). The protein and oil content of immature seeds from these pods varied from 18.1 to 21.2 and 2.1 to 2.2 percent, respectively. Pigeonpea, depending upon the variety, can also be used as an ornamental or vegetable plant in home gardens. The results of these experiments were quite encouraging.

497

## STUDIES ON THE PRODUCTION OF OFF-SEASON JEWS' MALLOW IN EGYPT.

A. F. Abou-Hadid; S. A. Gaafer*; M. Z. El-Shinawy; M. A Medany and A. S. El-Beltagy. Department of Horticulture, Faculty of Agriculture, Ain-Shams Univ., 11241 Hadack Shobra, P.O. Box 86 Cairo, Egypt.

Jews' Mallow (Melokhia) Corchorus olitorus, is a very important leafy vegetable for the Egyptians all year round, except for winter period. Short days and low temperatures accelerate the flower initiation and inhibits the vegetative growth entirely. Some supplimentary light of 8000 lux for one or two hours after sun-set, or as a flash for 10 min. at mid-night have been tried. The obtained results showed that two hours of artificial light after sun set inhibits the flowering and encourages leaf number , leaf area, plant height, plant fresh and dry weight, and leaf/height ratio. The obtained data were discussed in relation to the prevailed microclimatic conditions.

498

## KANGKONG - A PROMISING SUMMER LEAFY VEGETABLE OF BANGLADESH.

Asit K. Sarkar*, M.L. Chadha and A.K.M. Amzad Hossain Bangladesh Agril. Research Institute(BARI), Gazipur, Bangladesh.

There is shortage of vegetables in general in Bangladesh during rainy season. So, Kangkong (Ipomoea reptans) was introduced almost forty years back in Bangladesh as a fast growing nutritious green leafy vegetable suitable for growing during summer and rainy season. However, being a vine type vegetable, it quickly spreads over the land and leaves get soiled up, making them unsuitable for marketing. For search of an errect type variety the scientists of BARI were able to develop a line of kangkong which was released in 1983 in the name of **Gimakalmi**. This has become very popular in many parts of the country and thus contributing towards alleviation of vitamin A deficiency which is very much prevalent in the country. In the above context, two more kangkong lines, namely KG 002 (broad leaf) and KG 003 (pointed leaf) were introduced from AVRDC and their adaptibility and performance were evaluated during 1991. The leaf yield of KG 002 was found to be higher (46.0 t/ha) than Gimakalmi (35.8 t/ha) and KG 003 (32.0 t/ha). However all the lines were similar in growth habit and reaction to diseases and pests.

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# 211 ORAL SESSION 57 (Abstr. 499–505)
# Floriculture: Postharvest Physiology

499
LOW-TEMPERATURE STORAGE OF ALYSSUM, VINCA, NEW GUINEA IMPATIENS, AND TUBEROUS BEGONIA PLUGS
Royal D. Heins* and Thomas F. Wallace, Jr., Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

Alyssum, vinca, New Guinea impatiens, and tuberous begonia seedlings in plug cells were stored in coolers to determine the effects of temperature, light, and storage time on growth and forcing time of seedlings after transplanting. Optimum storage temperatures for each crop were also determined. Photosynthetic photon flux densities of 0, 1, and 5 $\mu$mol $m^{-2}$ $s^{-1}$ were combined with temperatures of 0.0, 2.5, 5.0, 7.5, 10.0, and 12.5C to create 18 storage environments. Sample plants were removed from each treatment at 1-week intervals for 6 weeks, and were forced into flower. Temperatures of 5°C or less caused chilling injury on New Guinea impatiens and vinca. No chilling injury occurred on Alyssum at any temperature while chilling injury occurred on tuberous begonia after 3 weeks at 0C. Flowering of New Guinea impatiens and vinca was not delayed on plants not damaged by chilling injury. Increasing duration of dark storage resulted in flowering delay of alyssum and tuberous begonia. As dark-storage duration increased, alyssum plants elongated, etiolated, and then died. In general, all plants stored better in the light than in darkness. Optimal storage temperatures were 0-5C for alyssum, 7.5-12.5C for vinca and New Guinea impatiens, and 5 to 7.5C for tuberous begonia.

500
ACCLIMATIZATION OF *CHRYSALIDOCARPUS LUTESCENS* WENDL.
Trinidad Reyes*, Terril A. Nell, and James E. Barret, Environmental Horticulture Department, University of Florida, Gainesville, FL 32611

A 3x3 factorial experiment in a split-plot design was conducted to evaluate interior performance of *Chrysalidocarpus lutescens*. Treatments included three irradiance levels (481, 820 and 1241 $\mu$mol $m^{-2}s^{-1}$) and three fertilizer rates (440, 880 and 1660 mg/23-cm pot, weekly). Plants were grown for 8 months under greenhouse conditions. Afterwards, plants were placed indoors (20 $\mu$mol $m^{-2}s^{-1}$ for 12 hr daily, 21 ± 1C and relative humidity of 50 ± 5%) for 3 months. At the end of the production phase, light compensation point (LCP) varied from 243 $\mu$mol $m^{-2}s^{-1}$ at the high irradiance level to 140 at the low irradiance level. Dry weight and nonstructural carbohydrates were lower and chlorophyll content was higher as irradiance levels were reduced. Increasing fertilizer to the highest rate decreased dry weight and nonstructural carbohydrates. After 3 months indoors, LCP declined to 126 $\mu$mol $m^{-2}s^{-1}$. Number of fronds increased in all treatments at the expense of reserved carbohydrates. However, the drastic carbohydrate depletion observed after the interior holding period (97% in stem starch and 62% in root starch ) indicates that *C. lutescens* is not a species for extended use under very low interior conditions

501
FACTORS ASSOCIATED WITH REDUCED POSTPRODUCTION QUALITY OF CHRYSANTHEMUM FOLIAGE PRODUCED UNDER HIGH NUTRITIONAL REGIMES
Stephen A.Carver* and Harry K. Tayama, Dept. of Horticulture, The Ohio State University, Columbus, OH 43210.

*Dendranthema grandiflora* Tzvelev., 'Spirit' and 'Torch' were produced under three water-soluble fertilizer (WSF) and one controlled-release fertilizer (CRF) regimes, with or without weekly $CaCl_2$ sprays during the last three weeks of production to evaluate their influence on postproduction foliar longevity. Foliage of plants produced with 400 mg·liter$^{-1}$ N (Peter's 20N-4.4P-16.6K) declined 1 to 2 weeks earlier than those produced with 400 mg·liter$^{-1}$ N (Hydro-sol + $NH_4NO_3$), and 3.5 to 5 weeks before plants fertilized with 100 mg·liter$^{-1}$ N (Hydro-sol + urea + $NH_4NO_3$) or 1 kg N·meter$^{-3}$ growing medium (Osmocote 14N-6.2P-11.6K). Calcium chloride had no influence on foliar longevity. Plants receiving either 400 mg·liter$^{-1}$ N treatment were generally larger (plant height and diameter), fuller (total and average leaf area), more vigorous (leaf dry weight per unit leaf area), and darker green in color ('Spirit' only, chlorophyll content per unit leaf area). Plant receiving WSF treatments had less than 0.5x the root system (dry weight) of CRF plants at harvest. Postproduction foliar longevity was most significantly and consistently correlated with foliar and growing medium nitrogen content. Relationship of postproduction foliar longevity with leaf soluble protein, carbohydrate, and starch content will be presented.

502
SUPPLEMENTAL SUCROSE INCREASES LONGEVITY OF MINIATURE POTTED ROSE FLOWERS
José A. Monteiro*, Terril A. Nell and James E. Barrett, Department of Environmental Horticulture, University of Florida, Gainesville, FL 32611.

Potted 'Orange Sunblaze' miniature roses, were grown under long days by night interruption from 2200 to 0200 HR. Flowering plants were moved to interior conditions (12 $\mu$mol $s^{-1}$ $m^{-2}$ from cool white fluorescent lights for 12 hr daily and 21 ±1C) when buds were showing color and sepals were beginning to unfold. A needle connected to a reservoir containing either water or a 3% sucrose solution was inserted into stems. One flower bud was selected on each plant and other buds and open flowers were removed. Flower longevity and amount of solution/water uptake were recorded. Flowers of plants receiving sucrose lasted 2 days longer than flowers receiving water (P=0.015) with longevities of 15 and 13 days for sucrose and water, respectively. Research is being completed to relate solution uptake to respiration and flower longevity. These data show that supplemental sucrose increases flower longevity in potted plants, similar to results with cut flowers.

503
EFFECTS OF LOW $O_2$ ON SENESCENCE OF CARNATION FLOWERS (*DIANTHUS CARYOPHYLLUS* L. cv. ELLIOTT'S WHITE)
Theophanes Solomos*, Department of Horticulture, University of Maryland, College Park, MD 20742-5611

Additions of adjuvants which inhibit the biosynthesis or action of $C_2H_4$ show that the climacteric rise in respiration during senescence of cut carnations is a facet of ethylene action and not senescence as such. The rate of $CO_2$ output of carnation flowers was diminished in a dose-dependent mode by low $O_2$. The data indicate that the diminution of respiration by low $O_2$ may not be attributed to the restriction of either of the mitochondrial terminal oxidases. The steady-state concentration of ATP was similar in both air and 2% $O_2$-treated flowers. 2% $O_2$ eliminated for 32 days any rise in $C_2H_4$ evolution. In addition the longevity of the flowers kept under 2% $O_2$ was longer than those which were treated with STS. The results are taken to indicate that hypoxia affects developmental events leading to the induction of $C_2H_4$ and/or the synthesis of transducer of $C_2H_4$ action.

504
ACTIVITY OF ADH AND ETHANOL PRODUCTION IN CARNATION FLOWERS TRANSFERRED TO $N_2$ FROM AIR AND LOW $O_2$
Xiuhua Chen* and Theophanes Solomos, Department of Horticulture, University of Maryland, College Park, MD 20742-5611.

Freshly harvested carnation flowers (*Dianthus caryophyllus* L. cv. White's Sim) were kept for 4 days either in air or low $O_2$ before they were transferred to $N_2$. Low $O_2$ in the range of 1.2-2.7% resulted, depending on the concentration, in a decrease in respiration and 3-5 fold increase in alcohol dehydrogenase (ADH) activity, without a concomitant increase in ethanol production. Anoxia initially, within 4 hours, depressed by about 40% the rate of $CO_2$ evolution in air, but had no effect on low $O_2$-treated flowers. Anoxia induced in all treatments an increase in the activity of ADH, but the levels of ADH were 1.5 fold higher in the low $O_2$-treated flowers than those kept in air. This difference increased to 10-fold after 6 days because by then, the air treated flowers were almost dead. Prior exposure to hypoxia enhanced the anoxic life of flowers by 3-4 days. Anoxia also induced an increase in ethanol production in both air and low $O_2$ treated flowers. The peak value of ethanol evolution was about 1.5-fold higher in the low $O_2$ than in air-treated flowers. The data are discussed in terms of the effect of hypoxia on carnation flower metabolism and longevity.

505
INHIBITION OF ETHYLENE BIOSYNTHESIS AND ACTION IN CUT CARNATION FLOWERS BY AMINOTRIAZOLE
Steven A. Altman* and Theophanes Solomos, Department of Horticulture, University of Maryland, College Park, MD. 20742

Treatment of carnation flowers (Dianthus caryophyllus L., cv Elliot's White) with 50 or 100 mM aminotriazole (ATA) for 4 days postharvest results in suppression of the respiratory climacteric and significant extension of vase life. ATA inhibited ethylene evolution and the ethylene climacteric via inhibition of the biosynthesis of ACC synthase. The inhibitory effects of ATA increased with time of exposure and concentration. Flowers treated with 50 or 100 mM ATA for 2 days exhibited a dose dependent climacteric



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increase in ethylene evolution and increased respiratory activity, in response to application of 10 µL/L exogenous ethylene. Senescence associated morphological changes, increased ACC synthase activity, ACC content, and ethylene evolution were completely inhibited in flowers treated for 4 days with 100 mM ATA. Although treatment with 50 mM ATA for 4 days did not completely inhibit components of the ethylene biosynthetic pathway, application of 10 µL/L exogenous ethylene failed to elicit any responses typically associated with carnation senescence, indicating that prolonged ATA treatment inhibited ethylene action. ATA may therefore serve as a useful tool in identifying molecular species involved in the perception or transduction of ethylene action.

# 212 ORAL SESSION 58 (Abstr. 506–512)
## Cross-commodity: Extension

506

INITIATING A STATE-WIDE HOME COMPOSTING PROGRAM

W.J. MCLAURIN and G.L. WADE, U. of Georgia, Athens, GA 30602

Sites in 12 locations throughout the state of Georgia were selected by the Department of Community Affairs. Each site contained up to eight types of composting bins and offered a self-guided tour with the appropriate signage at each of twelve stops.

The authors conducted meetings at 10 of the 12 sites. Using handouts, slide sets, videos, posters, hands-on demonstrations, and lectures, the demonstration team gave presentations designed to inform selected participants concerning the amount of home-generated compostable waste that currently goes into the landfills and the simple, "fail-safe" procedures they could use at home to turn this waste into an effective mulch/soil amendment for their yards and gardens.

Each participant received an information packet and a copy of The Home Composting Handbook, edited by the authors. During the meeting the demonstration team discussed composting structures, ways to build a backyard compost pile, and methods of maintaining the pile. Participants watched the actual building of a compost pile on site with materials typically found in local yards and gardens. Also, the demonstration team offered participants information on ways to involve the community and individuals within the community in implementation of home composting.

507

William T. Hlubik* and Richard B. Weidman, Rutgers Cooperative Extension of Middlesex County, 390 George Street, 8th Floor, New Brunswick, NJ 08901

The tremendous success of the Master Gardener Volunteer Program across the country, with more than 45,000 graduates, is a reflection of the nationwide interest in plants and gardening. Programs include students of all ages from diverse social, ethnic, and educational backgrounds.

The need for a model educational program to empower individuals and communities to assume responsibility for environmental stewardship has never been greater.

A new model program, The Master Gardener/Environmental and Community Stewardship Program, has been developed in order to incorporate environmental and horticultural topics and encourage successful environemntal stewardship education for adults. Combining horticultural and environmental education with related community volunteer projects provides a logic vehicle to encourage practical environmental stewardship.

508

PESTICIDE USE AND SAFETY PRACTICES OF INDIANA MASTER GARDENERS

Michael N. Dana*, B. Rosie Lerner, Ralph Gann, Timothy Gibb, Greg Shaner, Fred Whitford, and Ricky Kemery, Department of Horticulture, 1165 Horticulture Building, Purdue University, West Lafayette, IN 47907-1165

Indiana Master Gardeners were surveyed to determine their attitudes and practices related to pesticide use in the home garden and landscape. The data are of interest for the purpose of preparing educational programs for Master Gardeners and the public. Of the 1054 surveys mailed, 53.8% were returned with usable responses. When questioned about protective clothing worn during spray application of pesticides, most respondents indicated that long sleeves were not worn (57%), that long pants were worn (71%), that protective shoes were worn (76%) and that breathing protection was not used (80%). A median response of 0% of pesticides were reported to be stored in a locked cabinet. However, of those pesticides that were not in a locked cabinet, 74% were stored at least 4 feet off the floor. Master Gardeners with children reported locked storage of pesticides more often than those without children. Responses concerning disposal of containers indicate an area for future education. Only 54% of Master Gardeners reported rinsing their pesticide containers prior to disposing of them, while 73% indicated that the containers were included in the regular trash collection. Responses often varied with age, gender, and other demographic characteristics of the respondents.

509

MASTER GARDENERS' PERCEPTIONS OF ADEQUACY OF TRAINING IN PESTICIDE USE AND ORGANIC GARDENING

B. Rosie Lerner*, Michael N. Dana, Ralph Gann, Timothy Gibb, Greg Shaner, Fred Whitford, and Ricky Kemery, Department of Horticulture, Purdue University, West Lafayette, IN 47907

Indiana Master Gardeners were surveyed to determine their perceptions of adequacy of training related to pesticide use in the home garden and landscape. Respondents were also asked to indicate their attitudes regarding "organic" gardening practices and education. Of the 1054 surveys mailed, 568 were returned with usable responses. Of these responses, 217 had received some advanced training. More than 75% of respondents felt that their MG training was at least adequate in the areas of problem diagnosis, pesticide selection & use, and pesticide safety. MG training in non-conventional pest control methods was deemed inadequate by 43%. Organic gardening information and techniques were described as at least somewhat important by 92% of the respondents. Organic gardening methods are always practiced by 10%, usually practiced by 49%. MG training in organic gardening was described as thorough by 10% of the respondents, adequate by 47%, inadequate by 30%. No training was received in this area by 12%. Responses often varied with age, gender, and educational and training background of the respondent.

510

SAFE HANDLING OF PESTICIDES TRAINING IN COLORADO GREENHOUSES

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

In late 1992, a grant was received from the National Institute of Occupational Safety and Health (NIOSH) to conduct training programs on Safe Handling of Pesticides for employees at ten Denver-area greenhouses. The training program met Occupational Safety and Health Administration (OSHA) requirements for employee right-to-know and Hazard Communication Standards. Sessions in Spanish and English were held, involving two video presentations, discussions of Material Safety Data Sheets, and procedures in each greenhouse for employees' health and safety. Before and after quizzes were given to the English-speaking participants and indicated an average increase of 5.2 points (out of 27 possible) after program participation. Evaluations indicated that, on a scale of 1 to 5 (5 high), participants thought the training would be "helpful when I handle hazardous materials" - 4.4; "presentation was clear and understandable" - 4.6; and "understand Hazard Communication Standard" - 4.5. Due to illiteracy among many in the Spanish-speaking sessions, evaluation was extremely difficult.

511

DEVELOPMENT OF A COMPUTERIZED AGRICULTURAL WEATHER PROGRAM INCLUDING A FREEZE ALERT AND CHILLING ADVISORY

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

An initial effort began in 1987 to provide limited freeze forecast information to the fruit industry using a computerized program. This initial thrust at providing timely weather information to county agents and growers resulted in development of a sophisticated, user friendly program presently providing over 900 weather files daily to users. This program operates with a 420 Sun Server that automatically downloads files from the NWS office across the AU campus and makes them instantly available to county agent (CEA) offices via the Extension Network (Acenet). Growers may obtain information from CEAS or use their personal computers to access a "Weather Board" which provides the same weather products. Chilling models have been developed to provide growers information and predict guides for applying chemicals needed during mild winters. A very helpful freeze alert program is in place which includes four separate products which provide freeze predict forecasts and a commentary to supplement this information.



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GROWER SELF-EVALUATION AS AN EXTENSION TOOL
John F. Kelly*, Bernard H. Zandstra and Norman L. Myers, Department of Horticulture, East Lansing, MI 48824-1325

A self-administered response to production-related questions, based on the most recent recommendations for the production of asparagus, was used to identify strengths and weaknesses of growers on an individual or group basis. Points were assigned to the various responses, and growers were evaluated relative to the group of respondents. Individual grower evaluation summaries were returned to the county horticultural agent for use in individual grower consultations. This report discusses the specific issues related to asparagus production and presents factors to be considered in preparing and evaluating such a tool.

## 213 ORAL SESSION 59 (Abstr. 513–519) Cross-commodity: Propagation

513
PRE-GERMINATION TREATMENTS INFLUENCE GERMINATION AND PLANT SURVIVAL OF YUCCA GLAUCA GERMINATED ON LS MEDIUM
Jody J. Brott* and Paul E. Read, Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724

Seeds from three phenotypes of Yucca glauca were germinated using two pre-germination treatments for each phenotype. Treatments were: a 10% NaOCl (10 NaOCl) soak for 15 minutes and a 50% NaOCl (50 NaOCl) soak for 24 hours. Seeds were then placed on Linsmaier-Skoog (LS) medium in darkness for two weeks at 27-28 C. All radicles were emerging through the seed coats at the end of 50 NaOCl as compared to no visual difference in the seed appearance after 10 NaOCl. At the end of the two incubation periods, seeds from 50 NaOCl exhibited shoot development and elongation while seeds from 10 NaOCl exhibited little or no shoot development or elongation. Seeds from 10 NaOCl exhibited contamination and/or "bleeding" (phenolic exudates) within 4 weeks. All seedlings were transferred to fresh LS medium and cultured for 6, 12 and 18 weeks. Seedlings that received the 50 NaOCl developed fibrous roots at 8-10 weeks and the beginnings of a tap root at 16-20 weeks. Ten seedlings from 50 NaOCl were transplanted 9 months after germination.

514
TRANSPLANT TECHNIQUES & TIMING INFLUENCE SURVIVAL OF YUCCA GLAUCA TRANSPLANTS.
Jody J. Brott* and Paul E. Read, Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724

Juvenile Yucca glauca plants, with a fibrous, woody rhizomatous root still connected to the mother plant and well developed basal fibrous roots that were present when they were transplanted prior to tap root development, exhibited faster recovery from transplant stress and earlier bloom as compared with juvenile plants transplanted with fully developed immature taproots. All juvenile transplants exhibited >90% survival as compared with mature transplants with fully developed taproots, none of which survived. Juvenile transplants with no taproot development prior to transplanting recovered and produced flower stalks with full bloom within 2 years of transplanting. Juvenile transplants with taproot development took 3 years from transplant to recover and produced flower stalks with full bloom.

515
Effects of IBA and Branch Position on Rooting Softwood Cuttings of 'Yoshino' Cryptomeria
Laura G. Jull*, Stuart L. Warren and Frank A. Blazich, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Softwood stem cuttings of Cryptomeria japonica (L.f.) D. Don 'Yoshino' consisting of (1) tips (terminal 20 cm) of first order-laterals (secondary axes), (2) the distal half (terminal 10 cm) of tips of first-order laterals, (3) the proximal half (basal 10 cm) of tips of first-order laterals or (4) tips (terminal 10 cm) of second-order laterals (tertiary axes) were treated with 0, 3000, 6000 or 9000 ppm 1H-indole-3-butyric acid (IBA) and placed under intermittent mist for 12 weeks. IBA treatments did not effect percent rooting, root number, root length, or root dry weight. Tips of first-order laterals and the proximal half of first-order laterals yielded the highest rooting percentages (75% and 78%, respectively), whereas the distal half of the first-order laterals and tips of second order laterals rooted in lower percentages (50% and 34%, respectively). Tips of first-order laterals and the proximal half of first-order laterals both produced 4.5 roots per cutting. Root length, root area and root dry weight were also highest with these two branch positions.

516
DOSE RESPONSE CURVES AND CARRIER EFFECTS ON ROOTING
Brian K. Maynard* and William A. Johnson, Department of Plant Sciences, University of Rhode Island, Kingston, RI 02881.

Auxins are indispensable for vegetatively propagating many woody plants. The rooting of stem cuttings treated with auxin varies with shoot maturation, phenological age and stock plant nutrition. Sensitivity to applied auxin is important both practically and for understanding the physiology of root formation. Applying optimal auxin concentrations is often the key to successful cutting propagation. Auxin dose-response curves for rooting usually show increased rooting with increasing auxin concentration to an optimum, followed by rooting inhibition and phytotoxicity at supra-optimal rates. These curves will be used to analyze dose response kinetics for common rooting hormones and carrier formulations. Dose-response curves were developed, using cuttings of *Ilex glabra* - inkberry holly, to evaluate IBA and NAA dissolved in 50% aqueous ethanol (EtOH) or 40% aqueous polyethylene glycol (PEG). Few differences were evident in the response curves of auxin dissolved in EtOH or PEG at concentrations of 0 to 75 mM. PEG yielded higher root numbers at the optimal concentrations of 10-20 mM NAA and 30-50 mM IBA. Both the stimulation and inhibition of rooting were more sensitive to NAA than IBA. Decreasing root length and increasing basal rooting inhibition were good indicators of auxin toxicity. These results further our knowledge of carrier effects on rooting and the potential of dose response analysis for studying adventitious root formation in cuttings.

517
AUXIN INFLUENCES ROOT INITIATION AND DEVELOPMENT FOR CHIONANTHUS RETUSUS STEM CUTTINGS
D. Joseph Eakes', Charles H. Gilliam and Gary J. Keever, Department of Horticulture, Auburn University, AL 36849-5408

Terminal stem cuttings, 15.24 cm in length, of Chionanthus retusus Lindl. & Paxt. (Chinese Fringetree) were taken on 24 Sept. 1992. All cuttings were made from hardened off current years spring growth. The basal end of the cuttings were cut at an angle and treated with one of eight treatments before being stuck in a 100% vermiculite medium and placed under intermittent mist with a polyethylene covering. Treatments were: 3,000, 8,000 and 16,000 ppm IBA as K-IBA liquid quick dips and as commercial talc preparations (Hormex Nos. 3, 8 and 16), 10,000 ppm NAA as a quick dip, and an untreated control. Cuttings were harvested and evaluated on 10 Dec. 1992. All auxin treatments increased rooting %, average root length, total root fresh weight, and root rating when compared to the untreated control. Cuttings treated with 10,000 ppm NAA had the greatest rooting %, longest average root length, greatest root number, and highest root rating compared to the other auxin treatments, with the exception of the 16,000 ppm K-IBA quick dip treatment which was similar.

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518
FOLIAR DISEASES OF THE GROUND COVER, *VINCA MINOR* L., DURING NURSERY PRODUCTION
Mary C. Koelsch[1]*, Sharon L. von Broembson[2] and Janet C. Cole[1], [1]Department of Horticulture and Landscape Architecture and [2]Department of Plant Pathology, Oklahoma State University, Stillwater, OK 74078

The production of *Vinca minor*, a shade tolerant ground cover, has declined in recent years due to foliar diseases. Two fungal pathogens, *Colletotrichum gloeosporioides* and *Phoma exigua* var. *inoxydabilis*, were consistently observed on infected plant material from Oklahoma nurseries. Symptoms caused by *C. gloeosporioides* included severe anthracnose and stem dieback, while *P. exigua* caused leaf and stem lesions. The pathogenicity of two isolates of *C. gloeosporioides* and one isolate of *P. exigua* was evaluated on the native species and the cultivar 'Bowles' of *V. minor* to determine relative disease resistance of these plants. Specific environmental conditions for infection were determined by *C. gloeosporioides*. Infection was greatest at 28±1°C with high humidity and a light intensity of 126 $\mu mol \cdot m^{-2} \cdot sec^{-1}$. Five concentrations of eight fungicides (chlorothalonil, cupric hydroxide, mancozeb, propiconazole, San 619, thiophanate methyl, thiophanate methyl/mancozeb, and triforine) were used to test mycelial growth inhibition of the three isolates on amended agar. San 619 completely inhibited mycelial growth of *P. exigua*, and propiconazole inhibited growth of all three isolates at all concentrations tested.

519
AN INTRODUCTION TO MARINE HORTICULTURE
Kimon T. Bird, Center for Marine Science Research, University of North Carolina at Wilmington, Wilmington, NC 28403

We can think of marine horticulture as the production of specialty crops just as in conventional horticulture. Certain marine algae provide foods and have been cultivated for centuries. Ornamental marine plants find their way into the recreational and display aquarium market. Some are now used for landscaping. There is a large market in the U.S. for marine plants needed for environmental technologies. Marine botanists use a number of horticultural and biotechnological methods to provide steady supplies of these plants. Marine plant germplasm may also find future use in U.S. agronomy and horticulture. This paper will review these current uses and possible future applications of marine plants in horticulture.

## 214 ORAL SESSION 60 (Abstr. 520–527)
## Fruit: Stress Physiology

520
ALUMINUM-INDUCED CHANGES IN CARBOHYDRATE CONCENTRATIONS OF PEACH ROOTSTOCKS
Charles J.Graham* and Gregory L. Reighard, Dept. of Horticulture, Poole Agriculture Center, Box 340375, Clemson University, Clemson, SC 29634-0375.

A greenhouse experiment was conducted to assess the effects of increasing aluminum concentrations on carbohydrate levels of peach. Nemaguard and Lovell peach seedlings were grown in sand culture and irrigated daily with one-fifth strength Hoaglands solution containing Al rates of 0, 25, 50, and 100 ppm. Beginning at week 6, plants were harvested at two-week intervals over an 8-week treatment period, and tissues (root, stem, and leaf) were analyzed for soluble sugars and starch. Lovell had significantly greater concentrations of root sucrose, glucose, fructose, and sorbitol; stem glucose and fructose; and leaf sucrose, glucose, and fructose. Nemaguard contained significantly greater concentrations of root, stem, and leaf starch and total carbohydrates compared to Lovell. Increasing aluminum concentration resulted in a significant linear increase of starch in the root and stem tissue, but a quadratic response in the leaf tissue of both cultivars. Increasing rates of Al produced a decreasing curvilinear response in the concentration of glucose and fructose in roots, stems, and leaves. Analysis across harvest dates revealed that glucose and fructose declined curvilinearly in all tissues as the treatment duration increased. Starch concentrations increased curvilinearly in the roots and stems but decreased curvilinearly in the leaves when analyzed across harvest dates.

521
EFFECTS OF IN VITRO-FORMED ROOTS ON WATER STATUS AND PHOTOSYNTHESIS OF TISSUE CULTURE APPLE SHOOTS.
Juan C. Díaz*, Kenneth Shackel and Ellen Sutter, Department of Pomology, University of California, Davis, CA 95616.

Apple shoots were cultured in a MS medium with agar. Whole-plant stomatal conductance and net photosynthesis were measured in a temperature-controlled room with a modified steady state porometer coupled to an IRGA. The gas exchange cuvette was maintained at a steady 95% RH. Once a steady state conductance was reached, a light stimulus (about 350 µmol m-2 s-1) was applied to measure photosynthesis. At the end of the gas exchange measurements, shoot relative water content was determined. Rooted shoots had higher values stomatal conductance, net photosynthesis and shoot relative water content compared to shoots without roots. Both conductance and photosynthesis were correlated to shoot RWC. These results suggest that in vitro roots improve plant function, measured as conductance and photosynthesis, by allowing the plant to have a higher water status compared to shoots that lack shoots.

522
ENHANCED CONVERSION OF $^{14}$C-GLUCOSE INTO SORBITOL UNDER WATER STRESS IN MATURE APPLE LEAVES
Zhongchun Wang*, Bruno Quebedeaux, Jr. and Gary Stutte, Department of Horticulture, University of Maryland, College Park, MD 20742.

Studies were conducted to determine whether water stress stimulates the conversion of glucose (glu) to sorbitol (sor) in leaves. $^{14}$C-glu or $^{14}$C-sor was introduced through the cut stem of detached apple (Malus domestica Borhk.) shoots which previously experienced either water stress or no stress before excision. When shoots were labelled with $^{14}$C-glu, the $^{14}$C sugars in mature leaves were partitioned as follows: 38% glu, 20% fructose (fru), 24% sucrose (suc), 18% sor in well-watered (CK) shoots and 30% glu, 22% fru, 18% suc, 30% sor in water-stressed (WS) shoots. Water stress enhanced the conversion of $^{14}$C-glu to sor but reduced the conversion to suc and starch. When labelled with $^{14}$C-sor, the $^{14}$C sugars in mature leaves were partitioned as follows: 94% sor, 1% suc, 3% fru, 2% glu in CK shoots and 90% sor, 4% suc, 3% fru, 3% glu in WS shoots. Young expanding leaves and stems had lower $^{14}$C-sor, but higher $^{14}$C-suc, $^{14}$C-glu and $^{14}$C-fru levels than mature leaves. Our $^{14}$C data support the hypothesis that water stress stimulates the conversion of glu to sor.

523
SOIL MOISTURE RESPONSES AND RESULTANT CROP WATER STRESS INDEX FOR PEACHES IRRIGATED BY A WATER BALANCE COMPUTER MODEL
J.W. Worthington* and J.L. Lasswell, Texas A&M University Agricultural Experiment Station, Rt. 2 Box 00, Stephenville, TX 76401

Irrigation water applications were made to 'Majestic' and 'Redskin' peaches using micro-irrigation. Scheduling was done with a water balance computer model. Predicted application rates called for irrigation at 10%, 30%, and 50% depletion of available moisture in the wetted area. Neutron probe and tensiometers indicated that moisture levels were maintained at predicted levels. The crop water stress index as measured with an infrared thermometer were negatively correlated with soil moisture levels in the wetted area. Yields and fruit size increased with irrigation. Soluble solids and titratable acidity for irrigated and non-irrigated fruit were measured and data will be presented.

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524

GROWTH RESPONSES OF YOUNG APPLE TREES ON 3 ROOTSTOCKS TO DROUGHT STRESS

R.T. Fernandez*, R.L. Perry and J.A. Flore, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325.

'Imperial Gala' apple trees on M.9 EMLA, MM.111 and Mark rootstocks were subjected to two drought and recovery periods in a rainshelter. The objectives were to determine rootstocks adaptation and parameter sensitivity to drought stress. Leaf growth rate, area, emergence; shoot length, trunk cross sectional area and gas exchange were measured for each stress and recovery period. Leaf growth rate was most consistently reduced by drought and returned to control levels when irrigated. Length of less vigorous shoots was consistently reduced by stress but did not recover upon irrigation. Leaf emergence and trunk cross sectional area were inconsistent in response to stress. Growth of trees on Mark rootstock was reduced to the greatest extent by drought followed by MM.111 and M.9 EMLA. At termination plants were separated into roots, 1-year and 2-year shoot growth and rootstock to determine dry weights. Dry weights confirmed the growth measurements with a 34%, 27% and 16% reduction in total plant dry weight for drought stressed trees on Mark, MM.111 and M.9 EMLA, respectively. The greatest differences in estimated whole plant photosynthesis were for trees on Mark rootstock followed by MM.111 with the least differences for M.9 EMLA which reinforced the growth measurements. It was concluded that Mark was most sensitive followed by MM.111 with M.9 EMLA being most tolerant to drought.

525

RESPONSES OF YOUNG PEACH TREES TO ROOT CONFINEMENT

Mark Rieger* and Franco Marra, Department of Horticulture, University of Georgia, Athens, GA 30602.

Rooted cuttings of Nemaguard peach (*Prunus persica* (L.) Batsch.) were grown in 0.18, 0.36, 0.90, and 2.40 liter containers for 16 weeks to study the influence of root confinement on growth, gas exchange, water uptake, and leaf carbohydrate and nutrient content. Leaf area and stem length were reduced by root confinement beginning 6-7 weeks after transplanting, and differences among treatments increased through week 16. Final tree dry weights were reduced 51% over a 13-fold change in rooting volume, but dry weight partitioning was largely unaffected. Consistent reductions in $CO_2$ assimilation and leaf conductance for confined trees did not occur until after week 11. Sorbitol and starch accumulated earlier in leaves of trees in smaller containers, but sorbitol was reduced and starch was unaffected by container volume at week 16. Despite similar soil fertility, leaf nutrient concentrations were reduced ≈two-fold by root confinement, except N (reduced 38%), yet characteristic deficiency symptoms were not observed. Initial mechanism(s) limiting growth were not gas exchange rates, levels of nonstructural carbohydrates, or drought stress, although nutrient deficiency cannot be ruled out as a factor limiting growth of trees with restricted rooting volume.

526

CONVERSION OF BOUND TO FREE WATER IN ENDODORMANT APPLE BUDS

M.FAUST, D.LIU, M.J.LINE AND G.W.STUTTE . Fruit laboratory, and Environmental Chemistry Laboratory, Beltsville Agricultural Research Center, Beltsville, MD 20705 and Bionetics Corp. Kennedy Space Center,FL 32899.

Proton Density and T2 maps were created throughout the dormant season in 'Anna' and Northern Spy' apple cultivars. The percentige of oixels with 15-25 ms T2 time increased from 30% in both cultivars at the beginning of dormancy to 80 and 72% respectively, by the end of dormancy. The conversion in 'Anna' was rapid and in 'Northern spy was slow. Growth occured only when conversion of bound to free water reached 70% of the total number of pixels. Buds entered into a transitional phase when conversion of water reached 50%. Buds in the transitional phase are willing to respond to treatments aimed to end dormancy. Thus dormancy can be divided into two major part based on the boundness of freeness of water in the bud.

527

DROUGHT, LEAF GAS-EXCHANGE, AND WATER RELATIONS OF PAPAYA

Thomas E. Marler* and Michael V. Mickelbart, College of Agriculture & Life Sciences, Univ. of Guam, UOG Station, Mangilao, Guam 96923

A series of container studies was conducted from Sept. 1991 through July 1992 in which papaya plants were subjected to drying and re-wetting cycles to determine short term leaf gas-exchange and water relations responses to drought. The first response of papaya plants to a decline in substrate matric potential was a rapid reduction in stomatal conductance and net photosynthesis. Apparent quantum yield was reduced and light compensation point was increased shortly thereafter as stress continued to develop. However, leaf gas-exchange rapidly returned to the level of control plants after re-wetting. There was minimal or no effect of drought stress on relative leaf water content, pre-dawn xylem potential, dark respiration, the ratio of variable to maximum chlorophyll fluorescence, osmotic potential of leaf or root tissue, or root hydraulic conductivity of papaya plants. Chlorosis and shedding of the oldest leaves occurred following rewatering. These results indicate that papaya plants respond to short term drought by dehydration postponement via maintenance of water uptake and reduction of water loss.

## 215 ORAL SESSION 61 (Abstr. 528–535) Woody Ornamentals: Growth and Development II

528

NITROGEN AND CARBON TRANSLOCATION DURING EPISODIC GROWTH OF *LIGUSTRUM JAPONICUM* AND EFFECTS OF NITROGEN AND/OR LIGHT DURING DIFFERENT GROWTH EPISODES

Jeff S. Kuehny*, Dennis R. Decoteau, and Mary C. Halbrooks, Department of Horticulture, Clemson University, Poole Ag Building, Box 340375, Clemson, SC 29634-0375.

Pulse-labels of $^{15}N$ and $^{14}C$ were used to determine nitrogen and carbon translocation during episodic root and shoot growth. Stored nitrogen ($^{15}N$) was translocated to both the first and second episode of shoot growth. Autoradiographs of $^{14}C$ labeled plants indicated that fixed carbon was predominately translocated to roots during an episode of root growth and to shoots during an episode of shoot growth. Exclusion of nitrogen and/or light during different growth episodes decreased shoot length, leaf area, and fresh weight, thus affecting the root:shoot ratio for each episode. Translocation of newly fixed carbon and stored nitrogen between the shoots and roots of Ligustrum, and the supply of nitrogen and/or light are important factors that help maintain the functional balance of each episode of growth.

529

EFFICACY OF A COPPER HYDROXIDE/LATEX PAINT FORMULATION FOR ROOT - PRUNING 41 SPECIES OF CONTAINERIZED NURSERY STOCK

Randon J. Krieg* and W. T. Witte, Department of Ornamental Horticulture & Landscape Design, University of Tennessee, Knoxville, TN 37901-1071.

The root system of containerized nursery stock may become undesirably coiled or matted on the outer surface of the media. Various copper formulations painted on the interior of the container surface have been shown to control undesirable root growth in a few species. We tested a commercial formulation of 100 g/l copper hydroxide in a flowable latex paint formulation (SpinOut™) on 41 tree, shrub, and herbaceous species. Plants were grown 4 months in 7.5x7.5x15cm containers, either treated or untreated. Root density was evaluated on a scale of 1 to 5 (no roots on the surface to heavy rooting). Analysis showed treated containers prevented roots from growing on the media surface in all species tested except *Magnolia liliiflora* 'Jane', *Buxus sempervirens* 'Vardar Valley', and *Taxus x media* 'Hicksii', where control of surface rooting was significant but moderate. Copper paint did not inhibit growth of stolons or rhizomes, which morphologically are stem structures. No visual signs of copper toxicity were observed, nor were there any differences in shoot growth.



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530

COMPARISON OF ROOTS OF THREE MICROPROPAGATED CLONES OF *PRUNUS SEROTINA* VAR. *VIRENS* GROWN IN TWO SIZES OF CONTAINERS USING IMAGE ANALYSIS

Venu G. Oddiraju* and Caula A. Beyl, Department of Plant and Soil Science, Alabama A&M University, Normal, AL 35762

Three different lines of Chisos cherry obtained from trees with profuse or scant root systems were grown in either 2 or 3 liter containers to determine if the effects of container volume could be detected as early as 12 weeks. The root characteristics (profuse or scant root development) seen in the parent material were not shared by the clonal propagules from those lines. There was a significant effect of the clone on surface area of fine roots, coarse to fine root ratio, and root dry weight ($P<0.05$) and on surface area of coarse roots ($P<0.1$). The smaller container reduced root dry weight significantly ($P<0.1$) and coarse to fine root ratio ($P<0.05$). Using an image capture and analysis system (ICAS) to classify and quantify the roots of the microcuttings, an effect of container volume could be detected even though the experiment was terminated only 3 weeks after roots had encountered the container walls and began exhibiting a coiling response.

531

ROOT GROWTH OF SEEDLINGS AND MICROCUTTINGS OF *PRUNUS SEROTINA* VAR. *VIRENS* AS A FUNCTION OF COMPACTION

Venu G. Oddiraju* and Caula A. Beyl, Department of Plant and Soil Science, Alabama A & M University, Normal, AL 35762

Chisos cherry seedlings and microcuttings of two lines, one characterized by a profuse and the other a scant root system, were grown in compacted soils to study differences in their root development using an Image Capture and Analysis System (ICAS). Seedlings and microcuttings showed significant difference with respect to coarse root surface area, fine root surface area and root dry weight before they were placed under different compaction treatments ($P<0.05$). When final observations were made at 30 weeks, the compaction significantly restricted the growth of surface area of coarse roots and root dry weight ($P<0.05$) but not surface area of fine roots. Relative growth of coarse root surface area and dry weight in noncompacted soil was higher ($P<0.05$) than in compacted soil. Differences in coarse root and fine root surface area observed initially between seedlings and microcuttings disappeared over time.

532

INTERACTIVE EFFECTS OF ROOTING MEDIA AND PHOSPHORUS FERTILIZER ON ROOT ARCHITECTURE OF COLORADO MESQUITE

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

The effects of two rooting media [5 pine bark : 1 soil (v/v) and 5 Tufflite (a volcanic pumice) : 1 soil (v/v)] and (+ or -) phosphorus fertilizer [$Ca(H_2PO_4)_2H_2O$ @ 6.58 g P per pot] on root architecture of Colorado mesquite (*Prosopis alba* Grieb. 'Colorado') were studied. Rooted cuttings were transplanted into 10-liter containers, topdressed with 45 g of 20N-0P-16.5K (IBDU slow release formulation) and 3 g Micromax micronutrient fertilizer, grown outdoors on black polyproplyene fabric, and irrigated daily to container capacity for three months. With or without P, specific root length was less for mesquite roots in Tufflite than for those in pine bark. Without P fertilizer, extended path length and root altitude were higher for roots grown in Tufflite than for those in pine bark. Adding P fertilizer decreased specific root length regardless of media type. In the pine bark medium, root altitude and extended path length were highest for trees fertilized with P; however, P fertilizer did not affect root altitude and lowered the extended path length when trees were grown in the Tufflite medium. These results indicate that roots were thicker and more branched in the Tufflite medium compared to pine bark and that P fertilizer caused a more herringbone branching pattern for mesquite roots when grown in pine bark, but resulted in a slightly more dichomatous branching pattern for roots when grown in Tufflite.

533

INFLUENCE OF SPACING ON CUT FLOWER AND CUT STEM PRODUCTION OF FIELD-GROWN SALIX AND BUDDLEIA.

Allan M. Armitage* and Michael A. Dirr, Department of Horticulture, University of Georgia, Athens, GA 30602

Plants of *Salix alba* 'Britzensis' and *Salix chaenomeloides* were planted on 30, 60 or 90 cm centers in spring, 1992 and plants of *Buddleia davidii* 'Black Knight' were planted at densities of approximately 45, 80, or 165 cm centers in fall, 1991. Stems of *Buddleia* were harvested in the summer and fall of 1992 and those of *Salix* were harvested in the winter of 1993. The number of stems/plant decreased but the number of stems/$m^2$ increased with increasing plant density in all species. The stems of *Salix alba* 'Britzensis' were significantly longer in the highest plant density.

534

ROOT AND SHOOT GROWTH PERIODICITY OF GREEN ASH, SCARLET OAK, TURKISH HAZELNUT, AND TREE LILAC IN NEW YORK STATE

J. Roger Harris*, Nina L. Bassuk and Thomas H. Whitlow, Urban Horticulture Institute, 20 Plant Science, Ithaca NY 14853

Four each of landscape-sized *Fraxinus pennsylvanica* Marsh. (green ash), *Quercus coccinea* Muenchh. (scarlet oak), *Corylus colurna* L. (Turkish hazelnut) and *Syringa reticulata* Hara 'Ivory Silk' (tree lilac) were established on a rhizotron in Ithaca, New York, and root and shoot growth characteristics were observed throughout 1992. Root growth did not begin on any species before bud break. Green ash, scarlet oak and Turkish hazelnut exhibited recurrent shoot growth. Most root growth occurred during periods of bud rest, although no marked antagonism between shoot and root growth was evident. Green ash root growth was synchronous with shoot growth. The root harvest zone of green ash and tree lilac contained higher root length densities, and roots contained within appeared less suberized than that of Turkish hazelnut or scarlet oak. Root spread : crown spread ratio was greatest for Turkish hazelnut. Little root growth occurred on any species after fall leaf drop or when soil temperatures were below 5C. Implications for transplanting are discussed.

535

DIVERSITY AMONG SEEDLINGS OF *MAACKIA AMURENSIS*

William R. Graves and J. Giridhar B. Pai*, Department of Horticulture, Iowa State University, Ames, IA 50011-1100

Commercial production of *Maackia amurensis* Rupr. & Maxim. (Amur maackia) is very limited despite the ornamental and nitrogen ($N_2$)-fixing potential of this tree species. The goal of this on-going project is foster production efforts by selecting genotypes based on growth rate, morphology, stress resistance, and efficiency of $N_2$ fixation. To establish a collection of plants with diverse genetic backgrounds, we requested half-sib lots of seed from arboreta, public gardens, and zoos in 1991. Mean seed mass of the 38 lots that were obtained ranged from 35 to 99 mg. Germination ranged from 67 to 100% and was 78% for the oldest lot, which was harvested at least 66 years ago. Over 2500 seedlings representing the 38 lots were grown in a greenhouse during the 1992 season. The mean epicotyl length and number of compound leaves varied among seedlings in the different lots. Results to date indicate that selecting genotypes based on growth rate and morphological features will be possible.

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# POSTER SESSIONS 1–16 (Abstr. 550–955)

550 (PS 1)

IMPROVED EMERGENCE OF *SOLANUM TORVUM* BY SEED TREATMENT

H. Miura*, M. Yoshida and A. Yamasaki, Kurume Branch, National Research Institute of Vegetables, Ornamental Plants and Tea, 1823, Mii-machi, Kurume, 830 Japan.

Several soilborne diseases severely affect eggplants (*Solanum melongena* L.) in Japan. Therefore, eggplants are usually grafted on rootstocks of various species resistant to these diseases. For the control of verticillium wilt (*Verticillium dahliae* Klebahn), *Solanum torvum* 'Torvum vigor' plants are used for rootstocks. However since the seeds started to emerge after 12 - 14 days at 25C and only 40% of them emerged after 30 days, it was difficult to obtain seedlings of uniform size.

In this experiment, matric priming treatment of seeds prior to planting was modified to improve the emergence of the seeds of 'Torvum vigor'. Vermiculite powder was selected as the substrate to control the water potential of seeds during the treatment. First, samples of 0.25g seeds (235seeds on an average) were mixed with various amounts of vermiculite powder and water at 25C in the dark during 1 week. Thereafter, the treated seeds were planted in soil and incubated at 25C under a 12h daylength regime and the emergence and growth were monitored. Second, the temperature for the treatment, growth regulators added to water, air pressure and components, and the duration of the treatment were varied. Finally, the optimum treatment for improving the emergence of *Solanum torvum* seeds was developed.

551 (PS 1)

EFFECTS OF TESTA REMOVAL ON BROCCOLI SEED GERMINATION

Lewis W. Jett and Gregory E. Welbaum, Department of Horticulture, Virginia Polytechnic Institute & State University, Blacksburg, VA 24061.

The testae of seeds from the genus *Brassica* are not considered to constitute a significant barrier to radicle growth. It is hypothesized that in these seeds the testa splits during imbibition prior to the onset of radicle emergence. To test this hypothesis, the structural anatomy, the rate of hydration, the base water potential ($\Psi_b$), and the rate of germination of broccoli (*Brassica oleracea* L.) seeds were examined for both intact and decoated, primed and nonprimed seeds. Both primed and nonprimed seeds exhibited a marked increase in the rate of imbibition. The germination rates of primed and nonprimed decoated seeds were greater at all $\Psi$'s compared to intact seeds. Priming did not lower the $\Psi_b$ of intact seeds. Removing the testa reduced the $\Psi_b$ of both primed and nonprimed seeds. Observation of germinating seeds indicated that the testa was ruptured during the initial stages of radicle growth and not during the plateau phase of imbibition as previously believed. Priming did not appear to cause premature cracking or weakening of the testa. Priming did cause an irreversible change in volume due to free space that developed between the testa, radicle, and cotyledons. Thus, the testa of broccoli seeds does provide a barrier to radicle emergence that must be overcome by the expanding radicle during germination.

552 (PS 1)

EFFECT OF GRAIN SORGHUM ON GERMINATION OF WEED AND CROP SEEDS

M. L. Hoffman* and L. A. Weston, Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington, KY 40546.

Sorghum species are frequently used by horticultural producers as cover crops or green manures. Grain sorghum cover crops are often used in the southern United States. These summer annual grasses grow rapidly producing large quantities of biomass that has been shown to suppress weeds. Although allelochemicals in the roots and shoots have been identified, the precise mode of weed suppression has not been clearly elucidated. We performed a series of studies to evaluate the effect of sorghum on the germination of various weed and crop seeds. Petri dish assays were used to test the effect of germinating sorghum seed on the indicator species. Treatments were arranged in a completely randomized design with 4 replications and 2 experimental runs. Data collected included % germination as well as radicle and hypocotyl length. A modified Parker bioassay using 4 and 8 week old sorghum root and shoot tissue was used to study the effects of sorghum tissue on seed germination of the indicator species. Sorghum residue was observed to inhibit weed and crop seedling growth resulting in chlorosis of susceptible species.

553 (PS 1)

SEED TREATMENT EFFECTS ON VOLATILE ALDEHYDE PRODUCTION IN GERMINATING *sh2* SWEET CORN.

Thomas E. Paine* and Mark A. Bennett, Department of Horticulture, The Ohio State University, 2001 Fyffe Ct, Columbus, OH 43210-1096.

Seeds of two shrunken-2 (*sh2*) sweet corn (*Zea mays* L.) cultivars, 'Crisp'n Sweet 710' and 'Camelot', were used to relate volatile production to seed quality and seedling establishment. The five seed treatments evaluated were a hydration and drying cycle, a biological control of *Pythium*, a hydration and drying cycle followed by a biological control, a fungicide treatment, and an untreated check. For the aldehyde assays, 50 seeds were germinated in a flask for 24 h with a test tube of a 3-methyl-2-benzo-thiazolinone hydrazone (MBTH) solution. One ml of the solution was then reacted with $FeCl_3$, diluted with acetone, and absorbance read at 635 nm. A field study was run under cool soil conditions (10-16°C) for seedling emergence and growth. Aldehyde production from the seeds did not correlate with field results for seed treatments, but did show a distinct difference between cultivars. The biological control with the hydration and drying cycle significantly reduced aldehyde production. This may contribute to the effectiveness of biological treatments since *Pythium* spores can be stimulated by volatile compounds released from germinating seeds.

554 (PS 1)

PRIMING TEMPERATURE AND SALT CONCENTRATION EFFECTS GERMINATION OF PEPPER SEED AT LOW TEMPERATURES

Anne K. Carter*, NMSU Agricultural Science Center, Star Route Box 77, Clovis, NM 88101

*Capscicum annuum* L. var Vera Cruz seeds were primed at 15°C or 23°C for 5 days in 0, 200, 400, 600mM NaCl. The seeds dried for 3 days. Treatments plus an unprimed control were germinated in an incubator at 15° or 23°C . Germination was recorded daily and maximum % germination, (MaxG), mean daily germination (MDG) and $T_{50}$ were calculated. Treatments were as follows: 23°C prime, 23°C germination (23P23G), 23P15G, and 15P15G. The 0mM NaCl priming treatment had over 50% germination during the priming process, thus germination was not recorded. *P23G23* - MaxG was the same for all treatments . The $T_{50}$ and MDG were improved by approximately 2 days for the 200mM and 400mM treatments. *P15G15* - None of the seeds germinated in any of the treatments after 10 days. *P23G15* - The 200, 400, and 600mM priming treatments improved MaxG, MDG, and $T_{50}$ over the unprimed control, but were not different from each other. However, the MaxG was between 50-60% as compared to 90-95% in the P23G23 treatment. While priming at 23°C does allow seeds to germinate at cold temperatures, other treatments are necessary to improve MaxG.

555 (PS 1)

SOIL TEMPERATURE AND EMERGENCE OF WARM-SEASON VEGETABLES

Joanne Logan*, Marcella A. Mueller and Thomas B. Coffey, Department of Plant and Soil Science, P. O. Box 1071, The University of Tennessee, Knoxville, TN 37901-1071

In Tennessee, the 10% freeze probability dates occur during early April in most of the state. However, due to cool soils, most warm season vegetables are not planted until after May 1. The objective of this study was to quantify and map the soil temperature (2.5-5 cm depth) requirements for emergence of okra, sweet corn, cucumber, summer squash, snap bean and southern pea using different methods of temperature calculations. Field studies were conducted in Knoxville and Crossville, Tennessee in 1991 and 1992. Results show that the range of minimal average soil temperature for acceptable seedling emergence is 14 to 18°C, which is reached by mid-April in most of the state. Average soil temperature appears to be a better indicator of time to 50% emergence than other temperature-based calculations. It can be estimated from daily readings of present soil temperature in the early morning and mid-afternoon, or from air temperature, if necessary. Soil temperature maps, created in a geographic information system, can be very useful in selecting appropriate planting times for warm season vegetables.

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556 (PS 1)

EFFECT OF CELL SIZE ON THE GROWTH OF BROCCOLI AND CABBAGE TRANSPLANTS IN THE TOBACCO FLOAT SYSTEM

Carl E. Niedziela Jr.* and Phumulani Gumbi, Cooperative Extension Program, North Carolina A & T State University, Greensboro, NC 27420-1928

Two studies each were conducted with *Brassica oleracea* L. Italica Group 'Packman' and *B. o.* Capitata Group 'Greencup' cabbage. Seed was germinated and grown in a commercial soilless media contained in polystyrene flats floating on a nutrient solution from commercial fertilizers. The solution macronutrient concentrations (mM) were 6.4 $NO_3$, 4.3 $NH_4$, 0.5 $H_2PO_4$, 2.1 K, 2 Mg, and 2 $SO_4$. The solution micronutrient concentrations ($\mu$M) were 6.8 Fe, 4.7 $BO_3$, 3.4 Mn, 0.42 Cu, 0.30 Zn, and 0.008 $MoO_4$. Three cell sizes were used: 15 $cm^3$ (253 cells/tray), 26 $cm^3$ (200 cells/tray), and 36 $cm^3$ (128 cells/tray). Each cell had a depth of 6.5 cm. There were no differences in the mean plant height or weight of broccoli due to cell size in either experiment. There were also no differences in mean plant height of cabbage in either experiment. However, mean plant weight was heavier in the 36 $cm^3$ (5.4 g) cell size than the 15 $cm^3$ (3.4 g) cell size in the first experiment and heavier in the 36 $cm^3$ (3.9 g) and 26 $cm^3$ (3.4 g) cell sizes than the 15 $cm^3$ (2.8 g) cell size in the second experiment.

557 (PS 1)

LEAKAGE AND MOBILIZATION OF STORAGE RESERVES DURING IMBIBITION OF SWEET CORN.

G.B. McClure* and N.S. Lang, Department of Horticulture, Louisiana State University, Baton Rouge, LA 70803

Interconversion and transport of seed storage reserves during imbibition may influence subsequent germination. Sweet corn (*Zea mays* L. cv. Florida Staysweet) seeds were imbibed in aerated distilled water for either 0, 3, 6, 9, 12, or 24 h intervals. Seed leachate electrical conductivity, leachate soluble carbohydrate concentrations, and seed moisture were quantified at each interval. Lipid, non-structural carbohydrate, and protein concentrations of embryo and endosperm tissue were quantified for each imbibition interval. After imbibition treatments, seed germination performance was evaluated at 10 and 25C. Leachate conductivity and seed moisture increased with duration of imbibition. Glucose and fructose were the major soluble carbohydrates found in the seed leachate. Embryo lipid and sucrose concentrations significantly increased within 6 h of imbibition, while endosperm lipid decreased. Endosperm sucrose concentration remained constant throughout the duration of imbibition. Germination percentage was not significantly improved at 10 or 25C during the course of imbibition. Conversely, time to germination decreased significantly at 10C within 3 h. Storage reserve mobilization during imbibition may be responsible for the decreased time to germination observed at 10C.

558 (PS 1)

GROWTH OF RUSSETTED AND ROUND-WHITE POTATO OVER TIME AND MOISTURE REGIMES

S. B. Sterrett* and C. P. Savage, Jr., Eastern Shore Agricultural Experiment Station, Virginia Tech, Painter, VA 23420

Marketing opportunities exist for russetted potatoes harvested during July and August, but commercial production has not been economically feasible because of inadequate tuber enlargement. Distribution of dry matter between source and sink was compared over time for russetted and round-white cultivars under two moisture regimes in field trials for two years. Dry matter accumulation in above - ground (stems and leaves) and below-ground (roots and tubers) portions of round-white cultivars occurred significantly earlier than in russetted cultivars. Shoot-root ratios of round-white cultivars exceeded those of russets, indicating reduced yield potential for russetted cultivars in this growing area. Results also suggest that inadequate size distribution to meet marketing demands cannot be overcome by adjusting moisture regimes with the currently available russetted clones.

559 (PS 1)

TEMPERATURE EFFECT ON VEGETATIVE GROWTH OF CANTALOUPE

J. López*, A. alvarez and P. Valenzuela, Departamento de Agricultura y Ganaderia de la Universidad de Sonora, 8300 Hermosillo, Son. MEXICO

The objetive of this study was to determine plant growth characteristics of Cantaloupe (Cucumis melo) crop with different temperature regimes. The treatments consisted in four sowing dates.

Comparing the values of temperature, it was established the most suitable Growing Degree Days (GDD) and Threshold Temperature values of the plant.

This crop produces the firts harvest at 1152 and 1209 GDD with a 10 and 8oC of Threshold Temperature for cvs. 'Primo' and 'Cruiser', respectively.

Comparing these values with the temperatures recorded in other areas it could be easily determined the probability of vegetative growth stages.

560 (PS 1)

TRANSITION TO FLOWERING IN LETTUCE: EFFECT OF PHOTOPERIOD

William Waycott,* USDA-ARS, 1636 East Alisal Street, Salinas, CA 93905

A series of controlled environment experiments were undertaken to study the effect of daylength on the transition to flowering in lettuce (*Lactuca sativa* L.), a quantitative long-day plant. A wide range of domesticated and wild lettuces were grown at five different photoperiods (8, 10, 13, 16, and 20 hr $day^{-1}$) and measured for the number of days to 5, 10, and 30 cm. The results showed that the transition to flowering in lettuce is controlled by at least three different genetic systems: 1) a modified long-day system, typified by the American crisphead group, 2) a long-day system to which many of the European butterhead lettuces belong, and 3) the early flowering system. The first group was typified by a perceived non-linear response to daylengths between 10 hr and 13 hr, the response taking roughly the same number of days to flower under both of these daylengths. The second group showed a linear respond to incremental changes in daylength, while the crispheads were linear between 8 hr and 10 hr, and between 13 hr and 20 hr. This second group is known to have the long day gene *tag*, which induces rapid bolting in cultivars during long days. Our results indicate the effect of *tag* was no more than this linear response, and support the use of crispheads as a source of resistance to premature flowering, or bolting, for some time. The third system, early flowering, was nearly a day-neutral system. The plants flowered with a minimal response to increasing daylengths. Efforts of establish the exact physiological point of transition to flowering will be presented.

561 (PS 1)

EFFECT OF HIGH-$CO_2$ ATMOSPHERE ON PHENOLIC METABOLISM IN ROMAIN LETTUCE

Fatoumata Hamza*, Hélène Lambert, François Castaigne et Joseph Makhlouf, Département de Sciences et Technologie des Aliments, Faculté des Sciences de l'Agriculture et de l'Alimentation, Université Laval, Québec, Qc, Canada GIK 7P4.

The study aimed at establishing the role of phenolic metabolism in the development of "brown stain" (BS) of romaine lettuce (*Lactuca sativa* L.) stored under high $CO_2$. The lettuce were stored for 7 days at 4°C under a continuous stream of air or $CO_2$ (15%) in air, then transferred to air at 20°C for two days. Results indicate that the development of BS under $CO_2$ at low temperature was not related to activation of phenylalanine ammonia-lyase (PAL). After aeration of the produce the increase in BS symptoms coincided with the increase in phenol content of the tissue.

The data suggest that stimulation of phenol synthesis involved regulation of enzymes other than PAL, later in the phenyl propanoid pathway.



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562 (PS 1)

ANATOMICAL INVESTIGATION OF ESSENTIAL OIL GLANDS AND THIER DISTRIBUTION IN *OCIMUM BASILICUM* VARIETIES

C.L. Flinn*, R. Murray and J.E. Simon, Department of Horticulture, Purdue University, West Lafayette, IN 47907

Methyl cinnamate and citral, compounds used in large quantities by perfume and flavoring industries, are the major constituents of essential oils found in certain basil varieties. The composition and quantity of oil, sequestered in as many as 16 different types of glandular structures, however, has been shown to change over time with plant development. In this study, we used scanning electron microscopy to characterize glands associated with leaves and flower parts of 3 lines of *Ocimum basilicum*, 2 with a high percentage of metyl cinnamate and one with high citral (as rel. percent of total oil). Density and distribution of oil producing glands were visualized with a tissue printing method on adaxial and abaxial leaf surfaces of young, mature, and post-mature leaves. Scanning electron micrographs revealed the morphology of six types of glandular structures. Density of oil-producing glands decreased with leaf expansion. The tissue printing method allowed for rapid visualization of oil-containing glands. The density of resulting prints will be easily quantified with computer image analysis.

563 (PS 1)

SuperSorb-C AS A GROWTH MATRIX FOR $Ca^{2+}$ NUTRITION STUDIES OF DARK-GROWN SEEDLINGS

Patricia N. Myers*, James W. Cutler, and Cary A. Mitchell, Purdue University, Center for Plant Environmental Stress Physiology, West Lafayette, IN 47907-1165

SuperSorb-C (Aquatrols, Inc., Cherry Hill, NJ) has been used as a soil amendment in the horticultural industry for its tremendous water-holding capacity. However, the addition of nutrients to the medium, especially bivalent cations, greatly diminishes the ability of the copolymer acrylamide acrylate to absorb water. This study investigated the use of SuperSorb-C as the sole growth matrix for physiological investigations of hypocotyl elongation. Soybean seedlings were grown in a darkroom at varied levels of $Ca^{2+}$. Increased $Ca(NO_3)_2$ in the absorbing solution of the SuperSorb-C from 1 to 10 mM decreased the water-holding capacity of the copolymer from 96 ml $g^{-1}$ to 46 ml $g^{-1}$. The water potential of the medium was high for all $Ca^{2+}$ concentrations, ranging from -0.02 to -0.12 MPa. The average elongation rate of dark-grown soybean seedlings over a 54 h period increased from 0.9 to 1.1 to 1.4 mm $hr^{-1}$ with 1.0, 2.5, or 5.0 mM $Ca^{2+}$, respectively, then declined slightly with further increases in $Ca^{2+}$. The increased elongation rate was correlated with increased root development. SuperSorb has potential as a significant tool in the physiological studies of nutrient effects on plant growth and stress responses.

This project was supported in part by NASA grant NAG10-0093.

564 (PS 1)

YIELD CHARACTERISTICS OF A RICE CULTIVAR GROWN IN HYDROPONICS USING OPTIMIZED NUTRITIONAL REGIMES

Gayle M. Volk* and Cary A. Mitchell, NASA Specialized Center of Research and Training in Bioregenerative Life Support, Purdue University, West Lafayette, IN 47907-1165.

High yields and harvest indices in greenhouse studies indicated that japonica rice cultivar Ai-nan-tsao should be considered for inclusion in NASA's Controlled Ecological Life-Support Systems program. Ai-nan-tsao achieved a yield rate of 12.87 g $m^{-2}$ $d^{-1}$ when grown in continuously recirculating hydroponic systems under 12-h photoperiods in a growth chamber. Hydroponic systems have been improved such that contained plants have enhanced root development and a decreased edge effect. The total harvest index was 27% while shoot harvest index was 29%. A planting density of 775 plants m-2 resulted in an average of 5 tillers (and therefore 5 panicles) per plant. Average panicle weight was 1.5 g. Currently, various levels of nitrogen in the nutrient solution are being evaluated to attempt to shorten the life cycle and increase the harvest index. Nutritional analyses of the grain and inedible portions of the plants will identify changes in grain composition with respect to nutritional treatments relative to greenhouse soil culture. This project was supported in part by NASA grant NAGW2329.

565 (PS 1)

VEGETATIVE GROWTH OF POTATO UNDER SON AGRO HIGH-PRESSURE SODIUM, HIGH-PRESSURE SODIUM, AND METAL HALIDE LAMPS

N.C. Yorio*, C.L. Mackowiak, R.M. Wheeler, and J.C. Sager, The Bionetics Corp. (clm,ncy) and NASA Biomedical Operations and Research Office (rmw,jcs), Kennedy Space Center, FL 32899

The vegetative growth of potato (Solanum tuberosum L.) cvs. Norland (NL) and Denali (DN) was investigated comparing SON-AGRO high-pressure sodium (HPS-S), standard high-pressure sodium (HPS), and metal halide (MH) lamps. Plants were initiated from nodal culture and grown hydroponically in a reach-in growth chamber for 35 d with a 12-hr light/12-hr dark photoperiod and corresponding thermoperiod of 20/16 C. PPF for each treatment was maintained at 300 $\mu$mol $m^{-2}$ $s^{-1}$ and $CO_2$ levels maintained at 1000 $\mu$mol $mol^{-1}$ to promote growth. Results showed that main stem length (SL) and number of internodes (INT) for DN were significantly higher under HPS compared to MH, while HPS-S was not significantly different from the other lamp types. Total dry weight (TDW) of NL plants was significantly higher for HPS than for either HPS-S and MH, however there was no significant difference in SL and INT among lamp types. The data suggest that the 12.6% increase in blue light (400-500 nm) with HPS-S in comparison to conventional HPS lamps may not be sufficient to consistently decrease the stem elongation effects commonly seen with plants grown under HPS.

566 (PS 1)

ION ACCUMULATION IN PERICARP AND ENDOCARP OF CUCUMBER FRUIT AS INFLUENCED BY XYLEM AND PHLOEM IMPORT

Irvin E. Widders, Department of Horticulture, Michigan State University, East Lansing, MI 48824

Ion concentrations in pericarp tissue, 3.2% $K^+$, 0.9% $Ca^{2+}$, 0.57% $Cl^-$, 550 ppm $NO_3^-$-N, 0.51% $PO_4^{3-}$-P and 1.2% $SO_4^{2-}$-S on a dry wt basis, differed from that in endocarp tissue, 4.1%, 0.3%, 0.46%, 96 ppm, 0.72% and 1.3%, respectively, in 5 cm diam. cucumber fruit. Controlled environment experiments tested the hypothesis that xylem and phloem differentially supply pericarp and endocarp tissues with nutrients. Application of 6 mM Ca $(NO_3)_2$ during fruit development resulted in the pericarp having higher contents of $Ca^{2+}$ and $NO_3^-$ but not the endocarp. Shade (50% full sunlight) caused $Cl^-$ and $NO_3^-$ contents to decrease in both tissue. It was determined that xylem import could account for 73% and 100% of the total $Ca^{2+}$ in pericarp and endocarp, respectively, but only approximately 19% and 8% of the $K^+$. The role of xylem and phloem in supplying nutrients to developing cucumber fruits, as related to differences in transport of various ions within these two vascular systems, will be discussed.

567 (PS 1)

ROOT ZONE CUPRIC HYDROXIDE TREATMENT ENHANCES SUBSEQUENT GROWTH OF TOMATO, BUT NOT PEPPER, TRANSPLANTS

Joyce G. Latimer*, Department of Horticulture, Univ. of Georgia, Georgia Experiment Station, Griffin, GA 30223

'Sunny' tomato (Lycopersicon esculentum Mill.) and 'Jupiter' pepper (Capsicum annuum L.) seeds were sown in TODD 100A flats (Speedling, Inc.) treated with 100 g/liter cupric hydroxide applied to the root cell surfaces in a latex based carrier (Spin Out, Griffin Corp., Valdosta GA). Total root numbers were not affected by cupric hydroxide but initial root dry weight of 33-day-old tomato plants was reduced 30% by the treatment. Two-weeks after transplanting to sand-culture in the greenhouse, total root dry weight of treated transplants was 4% greater than that of untreated tomato transplants. The rate of shoot dry weight gain of treated transplants over 12 days of sand culture was slightly greater than that of untreated transplants. However, roots of 45-day-old pepper transplants were slower to recover from the copper damage. Initial root dry weight of treated plants was reduced 32% relative to controls. After two weeks of sand culture, root dry weight of treated plants was still 22% less than controls. Shoot growth of pepper transplants was unaffected. Root development inside the plug was particularly lacking indicating reductions in lateral root branching.

568 (PS 1)

EFFECT OF pH ON ROOT GROWTH OF SIX CULTIVARS OF WATERMELON

Aimin Liu*[1] Joyce G. Latimer[1] and Robert E. Wilkinson[2]
[1]Dept. of Horticulture, [2]Dept. of Agronomy, Georgia Experiment Station, The University of Georgia, Griffin, GA 30223-1797

Watermelon [Citrullus lanatus (Thumb) Matsum and Nakai] cultivars Charleston Gray(CG), Crimson Sweet(CS), Dixielee(DL), Jubilee(JL), Mirage(MG) and Starbrite(SB) were grown in white quartz flintshot sand and watered daily with 0.01M sodium acetate buffer at pH 4.0, 4.5, 5.0, 5.5, 6.0, or 6.5. After two weeks, stem length, leaf area, leaf and root dry weight, and root number were measured. Nnumber of root decreased with decreasing pH below pH 5.0 in all cultivars except CG, which had an increase trend. Root number of MG and SB had negative linear and quadratic correlations respectively, with decreasing pH. In all cultivars, root dry weight increased with decreasing pH below pH 5.5. Under pH≤4.5, all cultivars except CG, had short or no tap root and thickened lateral roots. CG had a



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decrease in stem length, leaf dry weight and leaf area with increasing pH, and was sensitive to high pH. However, MG and SB had reduction in leaf area and stem length with decreasing pH, which suggests that MG and SB are sensitive to low pH. Although there were no differences in shoot parameters of 2wk-old plants of CS, DL and JL, observations made at 7 days after seeding indicated a possible pH effect on early growth of seedling.

569 (PS 1)

**CORN YIELD VARIABILITY AND UPTAKE OF VARIOUS NUTRIENTS IN RESPONSE TO PHOSPHORUS FERTILIZATION IN LOW-P SOILS**

**B. Warren Roberts* and Michael W. Smith, Wes Watkins Agricultural Research & Extension Center, OK. State Univ., Box 128, Lane, OK 74555 and Dept. of Horticulture & L.A., OK. State Univ., Stillwater, OK 74078**

**Phosphorus was either banded, broadcast, or incorporated into raised beds at 33, 66, 99, or 132 kg · ha$^{-1}$. Sweet corn was planted in two rows 30 cm apart on the beds. Substantial differences in plant growth were observed between the two rows on each bed. Yield response to P treatments was masked by this variability. Plant tissue samples were collected at mid-season and at harvest time, and were analyzed for P, K, Ca, Mg, Zn, and Fe. Strong positive correlations were found between corn yield and plant Fe content, and strong negative correlations were found between corn yield and plant Zn content. Phosphorus content of tissue was positively correlated with plant Fe and negatively correlated with plant Zn content. Differences in plant height measured at mid-season could not be explained by nutrient concentrations in the tissue at that time. Corn ear yield was best explained by Fe concentration of the shuck (positive correlation), and by zinc concentration of the foliage (negative correlation) at harvest time. The range in ear weight was greater with the banded P treatments than with broadcast or incorporated P.**

570 (PS 1)

EFFECT OF NITROGEN FERTILIZER ON NITROGEN ACCUMULATION BY COMMON BEAN (*Phaseolus vulgaris*)

M. Mera*, J. Nienhuis and K.A. Kmiecik, Department of Horticulture, University of Wisconsin, 1575 Linden Drive, Madison, WI 53706-1590

Legume plants capable of fixing $N_2$ in the presence of abundant N in the soil are desirable to better integrate legumes into crop rotations including high N-demanding cereals. It has been suggested that the exotic bean line 'Puebla 152' may be insensitive to nitrate levels that normally inhibit bean nodulation and/or rate of fixation. Four levels (0, 30, 60, 120 Kg N/ha) of N as $^{15}$N-depleted ammonium nitrate were partialized into five weekly applications and imposed on Puebla 152, snap bean 'Eagle', and non-nodulating soybean 'Clay', in field experiments conducted in 1991 and 1992 on a very low N soil. CIAT's non-nod bean line Nod 125 was included in 1992. Each increment of added N increased the total N accumulated by the plants, in all genotypes. No significant genotype x N fertilizer interactions were detected. In average, Puebla 152 accumulated 25 and 46% more N than Eagle and Clay, respectively, in 1991, and 53, 119 and 119% more N than Eagle, Clay and Nod 125, respectively, in 1992. The analysis of $^{15}$N to estimate the proportion of N derived from the atmosphere is underway and will be presented at the meeting.

571 (PS 1)

EFFECT OF NITROGEN AND SULFUR FERTILIZATION ON THE CHEMICAL COMPONENTS OF FLAVOR IN SHRUNKEN-2 SWEET CORN

A. D. Wong*, J. M. Swiader, and J. J. Juvik, Department of Horticulture, University of Illinois, Urbana, IL 61801

Dimethyl sulfide (DMS), the compound responsible for the characteristic "corny" aroma, and sugar are the principle chemical components of flavor in sweet corn. It was our contention that it may be possible to enhance the flavor potential of some high-sugar sweet corn hybrids by supplying increased amounts of N and S fertilizer to the crop to increase kernel DMS and sugar content. A factorial combination of two N (168, 310 kg/ha) and three S rates (0, 34, 101 kg/ha) was applied to six *sh-2* sweet corn hybrids in a Plainfield sand. Kernel DMS and sugar levels were assayed over a period ranging from 20 to 29 days after pollination. In each case, kernel DMS and sugars decreased with increasing harvest maturity. In three hybrids, there was a positive response in kernel DMS to either N or both N-S. Kernel fructose and glucose concentrations tended to decrease as N fertilization rate increased, while sucrose levels remained relatively constant. In all hybrids, S fertilization had no effect on kernel sugars. The results indicated that it may be possible to increase kernel DMS potential in some genotypes by increased N fertilization, and to a lesser degree, from S application.

572 (PS 1)

SUITABILITY OF BLUEGRASS RESIDUES AS AN AMENDMENT IN CONTAINER MEDIA.

Robert R. Tripepi[1]*, Leslie K. Manning[1], Alton G. Campbell[2], Plant Science Division[1] and Forest Products Department[2], University of Idaho, Moscow, ID 83844-2339

Disposal of plant residues from bluegrass seed production is a potential problem for the grass seed industry, yet the residues may be useful as an organic amendment in container mixes. Postharvest residues of *Poa pratensis* L. 'South Dakota' were composted alone, tub ground and composted, mixed with amendments (cattle manure [M] or alfalfa seed screenings [AS]) and composted, or left alone (raw). All residues were ground to 4 to 6 mm segments and mixed with peat moss and perlite (2:1:1 by volume). Selected chemical properties and growth of tomato seedlings (*Lycopersicon esculentum* Mill. 'Laura') in the media were measured. Cation exchange capacity of the composted residue + AS medium was 50% greater than that of any other media, but electrical conductivity of this medium was also double that of all other media. Tomato seedlings grown in composted residue + AS medium had at least 3.5- and 4-fold more shoot dry weight and leaf area, respectively, than plants grown in other media. In addition, seedlings grown in composted residue + AS medium had 34 and 41% more shoot dry weight and leaf area than plants grown in 75% peat moss/25% perlite medium. Composted residue amended with AS appeared to be suitable as a peat moss extender in container media.

573 (PS 1)

IRON BIOAVAILABILITY FROM AMARANTHUS SPECIES

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

Genetic variability in iron bioavailability was examined in different species of Amaranthus, in order to attempt to improve the iron nutritional quality of this vegetable. 35 lines of Amaranthus, surveying 12 species, were selected from the collection at the plant introduction station at Ames, Iowa. These lines were direct seeded at the MSU Horticulture Research Center. 18 lines were harvested on days 28, 35, and 42 after planting, and the other lines were harvested only on day 35. Lyophilized leaf material was analyzed for total iron using atomic absorption spectroscopy. Bioavailable iron was estimated using an invitro assay simulating gastrointestinal digestion. Statistically significant differences in both total and available iron were detected among species and between harvest dates. Total iron concentrations increased from day 28 to 35 and then were decreased on day 42 for all species except A. tricolor. This species accumulated the highest concentration of iron in the leaves of all species examined, increasing to day 42. The bioavailable iron measured was also highest in A. tricolor, yet as a percent of the total iron, this species had the smallest fraction of iron available.

574 (PS 1)

MANGANESE CRITICAL LEVELS FOR EARLY SWEETPOTATO GROWTH.

D. G. Mortley*, G. W. Carver Agricultural Experiment Station, Tuskegee University, Tuskegee, AL 36088.

The effects of 0.25, 1.0, 2.5, 10, and 100 mg/liter of Mn on sweetpotato [Ipomoea batatas (L.) Lam.] were evaluated in 1990 and 1991 by use the nutrient film technique (NFT). A modified half strength Hoagland solution with $MnCl_2$ as the Mn source was used. Foliage and storage root dry weights declined linearly with increasing Mn concentration in whole plants, the decline occurring when Mn concentration approached 1000 ug/g. Storage root growth was severely restricted when Mn concentration in fibrous root reached 200 ug/g while foliage dry weight showed a more moderate decrease. Mn concentration was higher in the foliage than in fibrous roots. Roots of plants showed browning at higher (10 or 100 mg/liter) Mn concentrations in solution, which was stained blue with benzidine and bleached with oxalic-sulfuric acid solution, indicating the presence of oxidized Mn. Characteristic toxicity symptoms were observed in plants receiving 2.5, (moderate) 10 or 100 mg/liter Mn in solution. These results suggest that a Mn concentration of approximately 1000 ug/g in whole plants and 100 ug/g in fibrous roots are critical concentrations with respect to Mn toxicity in sweetpotato.



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575 (PS 1)

INFLUENCE OF POULTRY LITTER ON TOMATO YIELD, NUTRITION, AND SOIL CHEMISTRY

M. L. Baker*[1], D. R. Earhart[2], and V. A. Haby[2], Texas Agricultural Extension Service[1], Texas Agricultural Experiment Station[2], Overton, TX 75684

Composted poultry litter (PL) containing 2.98% N was hand-applied on individual plots in a RCB design with 3 replications. Rates (0, 8.2, and 16.3 Mg·ha$^{-1}$) were based on N content of the PL and requirement for maximum tomato production. Comparisons were made with a fertilizer blend (FB) containing 558 kg·ha$^{-1}$ of 14.1N-5.7P-9.2K applied in split application. 'Summer Flavor 5000' tomato plants were hand-planted 46 cm apart in rows spaced 3 m apart. Plant volume and average fruit weight were not influenced by any treatment. A 5920 kg·ha$^{-1}$ yield increase was noted when PL rate was increased from 0 to 8.2 Mg·ha$^{-1}$. Total yield was further increased 2757 kg·ha$^{-1}$ by doubling the PL rate. Yields due to FB were lower but not significantly when compared to PL rates. This decrease in yield could possibly be attributed to FB lowering soil pH to borderline levels for production (5.7) while litter rates had little effect on pH. No differences in leaf P and K were measured. Both rates of PL decreased leaf Ca but increased Mg as rate increased. There was no difference in leaf N, P, K, Ca, or Mg when zero PL and FB were compared. FB increased soil $NO_3$-N in the 0- to 30-cm depth zone more than the PL treatments. When comparing the highest PL rate to the lowest, there was almost a one and one-half time increase in residual soil K at the 0- to 15-cm soil depth. PL increased soluble salts only in the 0- to 15-cm soil depth, however, levels were low.

576 (PS 1)

UTILIZING POULTRY LITTER AS A FERTILIZER: SWEET CORN YIELD, MINERAL NUTRITION, AND SOIL CHEMISTRY

D. R. Earhart*[1], V. A. Haby[1], and M. L. Baker[2], Texas Agricultural Experiment Station[1], Texas Agricultural Extension Service[2], Overton, TX 75684

Composted poultry litter (PL) containing 2.98% N was hand-applied to plots in a split-plot design with 3 replications. Application frequency (total, split) was the major plot and rate (0, 10.9, 21.7, and 43.6 Mg·ha$^{-1}$) was the sub-plot. Rate was based on total N content of the PL and N requirement for maximum sweet corn production. Comparisons were made with a fertilizer blend (FB) containing 23.8N-4.3P-4.1K at a total rate of 564 kg·ha$^{-1}$ in split applications. Leaf area and average ear weight of sweet corn ('Merit') were not affected by frequency or rate. Increasing PL rate from 10.9 Mg·ha$^{-1}$ to 21.2 Mg·ha$^{-1}$ increased yield by 3128 kg·ha$^{-1}$. An increase to 43.6 Mg·ha$^{-1}$ decreased yield which was probably due to an observed reduction in plant stand. When comparing FB with 10.9 Mg·ha$^{-1}$ PL, the yields were equal. Plant P and K concentrations were increased linearly by PL rate. There were no differences in % N or mg·kg$^{-1}$ Ca and Mg. The highest soil $NO_3$-N concentrations in the 15- to 30-cm depth range were produced by 43.6 Mg·ha$^{-1}$ PL (15 mg·kg$^{-1}$) and FB (35 mg·kg$^{-1}$). Only the high litter rate increased soil $NO_3$-N below 30 cm. As PL rate increased, there was a corresponding increase in soil P. There was a linear increase in soil K from 60 to 200 mg·kg$^{-1}$ as rate increased. A linear decrease in pH was noted when PL rate increased. Soil EC was almost 2 times higher in the 43.6 Mg·ha$^{-1}$ PL plots than the next highest rate (275 vs. 150 umhos·cm$^{-1}$).

577 (PS 1)

CILANTRO AND DILL RESPONSE TO NITROGEN FERTILIZER RATES

Muddappa Rangappa*, Harbans L. Bhardwaj, Ali I. Mohamed, and Anwar A. Hamama. Agricultural Research Station, Virginia State University, Petersburg, VA 23806

Two separate experiments were conducted during 1992 to determine optimum rate of nitrogen fertilizer for cilantro (Coriandrum sativum L.) and dill (Antheum graveolens L.) production in Virginia. Three varieties of cilantro and two varieties of dill were used. The experiments were planted on July 28 and August 26 with three nitrogen rates (100, 200, and 300 kg/ha) and fresh weights (30cm row length from each plot) were recorded periodically during the vegetative growth. Generally, the nitrogen did not affect the yield indicating that soil nitrogen plus 100 kg of applied nitrogen per hectare was adequate for optimum growth of both cilantro and dill. At 45 days after planting (DAP), C1410 had the highest fresh yield of 1.8 kg/m whereas at 66 DAP the highest yielding variety was 18135 in both plantings (7.1 and 3.1 kg/m, respectively for first and second plantings). The differences between dill varieties were non-significant except with the second planting where Bouquet significantly outyielded Dukat at 70 DAP. The analyses to determine effects of varieties, nitrogen rates, and plant age on chemical properties of cilantro and dill is continuing and will be presented.

578 (PS 1)

$C_3$ AND $C_4$ PLANT RESPONSES TO PHOSPHORUS-LIMITING ENVIRONMENTS

Marilou Halsted*, and Jonathan Lynch, Department of Horticulture, The Pennsylvania State University, University Park, PA, 16802

The anatomical and biochemical characteristics of $C_4$ plants may make them more efficient than $C_3$ plants in nutrient deficient environments. A greenhouse pot study was conducted in the summer of 1992 to compare the responses of six $C_3$, four $C_4$ and two $C_3$-$C_4$ intermediate species to three levels of phosphorus nutrition: adequate, deficient, and severely deficient. Severely deficient P nutrition reduced shoot weight by 74% and 85% on average in the $C_3$ and $C_4$ species, respectively. $C_3$ plants appear to be more efficient than the $C_4$ in producing shoot biomass under stressful P conditions and two genera having $C_3$, $C_4$ and $C_3$-$C_4$ intermediate species exhibited a trend in the order of $C_4$(least efficient) $C_3$-$C_4$ intermediate, $C_3$(most efficient). P nutrition was more significant than species or plant type in determining both the concentration of P in plant tissues and the carbon dioxide exchange rate (CER). A more detailed study is underway to compare biomass partitioning and P allocation schemes of these $C_3$ and $C_4$ and $C_3$-$C_4$ intermediate type plants.

579 (PS 1)

COMPARISON OF THREE BONEMEAL PRODUCTS ON GROWTH OF 'PILGRIM' TOMATO

Kimberly A Klock* and Henry G. Taber, Horticulture Dept. Iowa State University, Ames, IA 50011

Three commercially available bone meal products, meat and bone meal, steamed bone meal, and bone chips were compared with Ca $(H_2PO_4)\bullet H_2O$ for their effectiveness in phosphorous availability. These products were added to a soil media (20 soil: 40 peat: 40 perlite by volume) at rates to give 0, 50, 100, 200, and 400 mg P•kg$^{-1}$. Products effectiveness was evaluated by growth and P uptake of 'Pilgrim' tomato (Lycoperisicon esculatum Mill.). Difference in plant dry weights among the products were significant at P≤0.02, with the greatest difference occurring between the control & the bone meal products. Differences were also evident among the products with respect to shoot P content (mg P•shoot $^{-1}$). A significant interaction between product & rate was observed for foliar P concentration, but not shoot P content reflecting a growth dilution effect. Therefore, the three bone meal products were equally effective in providing P for optimum tomato growth.

580 (PS 2)

**LIGHT INTENSITY AND DROUGHT AS PREDISPOSITION FACTORS FOR DOGWOOD ANTHRACNOSE**

Dan Erbaugh*, Mark Windham, Ann Stodola and Robert Augé, Dept. of Ornamental Horticulture, P.O. Box 1071, University of Tennessee, Knoxville, TN 37901-1071

Environmental factors regulating spread of dogwood anthracnose remain largely unstudied, so we conducted a two-year experiment to determine if light intensity or drought can affect this disease. After leaf emergence in 1990, two-year-old potted dogwood trees (*Cornus florida* L.) were placed outdoors in shade huts giving light treatments of 100%, 50%, 10% or 2% ambient light. One year later, trees were removed from huts to inoculate them (artificially or naturally) with *Discula destructiva* Redlin sp. Nov. After inoculation, trees were returned to their former light treatments and some of the trees were subjected to drought. Disease progression, quantified as increasing percentage of leaves with lesions, was unaffected by inoculation procedure. Light did affect the disease; by the end of the experiment, disease percentages in well-watered trees were 30% at 10% light, 15% at 2% light and below 5% at 100% and at 50% light. Drought increased disease progression on all shaded trees, ultimately 8x at 50% light, 1.4x at 10% light and 2x at 2% light.

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581 (PS 2)

**DROUGHT RESISTANCE STRATEGIES OF FOUR NATIVE ORNAMENTAL PERENNIALS**

Douglas S. Chapman and Robert M. Augé*, Dept. of Ornamental Horticulture, University of Tennessee, Knoxville, TN 37901-1071

We characterized the drought resistance of four native ornamental perennials: purple coneflower (*Echinacea purpurea*), orange coneflower (*Rudbeckia fulgida* var. *Sullivantii*), beebalm (*Monarda didyma*) and swamp sunflower (*Helianthus angustifolius*). We measured (a) stomatal conductance as leaves dried, (b) lethal water status values and (c) leaf osmotic adjustment during the lethal drying period. Maintenance of stomatal opening as leaves dry, low lethal water status values and ability to osmotically adjust indicate relative drought tolerance, with the reverse indicating drought avoidance. *E. purpurea* had low leaf water potential ($\Psi_L$) and relative content (RWC) at stomatal closure, and low lethal $\Psi_L$ and RWC. *R. fulgida* var. *Sullivantii* had a similar low $\Psi_L$ at stomatal closure, low lethal $\Psi_L$ and displayed relatively large osmotic adjustment. *M. didyma* had the highest $\Psi_L$ and RWC at stomatal closure and an intermediate lethal $\Psi_L$, yet displayed a relatively large osmotic adjustment. *H. angustifolius* became desiccated more rapidly than the other species despite having a high $\Psi_L$ at stomatal closure; it had a high lethal $\Psi_L$ and displayed very little osmotic adjustment. Despite differences in stomatal sensitivity, dehydration tolerance and osmotic adjustment, all four perennials fall predominantly into the drought avoidance category.

582 (PS 2)

**MYCORRHIZAE AND NONHYDRAULIC SIGNALLING IN SORGHUM EXPOSED TO PARTIAL SOIL DRYING OR ROOT EXCISION**

Robert Ebel*, Xiangrong Duan, Ann Stodola and Robert Augé, Institute of Agriculture, University of Tennessee, P.O. Box 1071, Knoxville, TN 37910

Our objectives were to determine (a) if mycorrhizal (VAM) fungi can alter drought-induced, nonhydraulic regulation of shoot growth, and (b) how much of a root system can be dried or severed before hydraulic effects on shoot responses become evident. Sorghum was grown with roots equally divided among four pots. The 2x2x4 factorial design had two levels of mycorrhizae (± *Glomus intraradix*), two levels of root treatment (dried or severed) and four levels of amount of roots treated (0, 1, 2 or 3 pots dried or severed). Neither leaf water potential ($\Psi$) nor Cs were affected by drying 1 or 2 pots, and reductions in leaf area in these plants were therefore attributed to nonhydraulic signalling. When 2 pots were dried, leaf growth was reduced less in VAM than in nonVAM plants, despite lower P in VAM leaves and despite quicker soil drying by VAM roots. Drying or severing roots of 3 pots did result in drops in leaf $\Psi$ and Cs, indicating a likely hydraulic effect on leaf water status in those plants. Leaf P declined progressively as more roots were dried or severed, possibly also affecting growth in plants with roots in 3 pots dried or severed. Leaf extension rates (LER) declined with only slight drops in soil $\Psi$, and LER declines were related to volume of soil drying. In VAM plants, leaf area reductions were correlated with length of time roots were exposed to soil $\Psi$ between -0.02 and -0.50 MPa.

583 (PS 2)

**MYCORRHIZAL SYMBIOSIS AND NONHYDRAULIC SIGNALLING OF SOIL DRYING IN CORN GIVEN VARIED P FERTILIZATION**

Robert Augé*, Xiangrong Duan, Robert Ebel and Ann Stodola, Institute of Agriculture, University of Tennessee, P.O. Box 1071, Knoxville, TN 37910

In *Zea mays* L. plants grown with roots divided between two pots, we tested (a) if leaf P concentration can affect nonhydraulic root to shoot signalling of soil drying, and (b) if a mycorrhizal (VAM) effect on signalling can occur independently of a VAM effect on leaf P. The 2x3x2 factorial design had 2 levels of mycorrhizae (± *Glomus intraradix* Schenck & Smith), 3 levels of P fertilization and 2 levels of water (both pots watered, or one pot watered while the other was allowed to dry). Total leaf length and shoot dry weight were not reduced in half-dried VAM plants, but each measure was ultimately reduced about 10% in half-dried nonVAM plants. Stomatal conductance (Cs), unaffected by VAM, was lower in half-dried, high-P plants than in high-P controls a few times during the latter half of the experiment, by as much as 65%. Leaf water potentials were not affected by partial soil drying, and reductions in leaf growth preceded reductions in Cs; hence, growth reductions were attributed to nonhydraulic signals coming from roots in drying pots. VAM x water and P x water interactions indicated that mycorrhizae influenced signal effects on final plant leaf length and that P fertilization influenced signal effects on Cs. Soil water potential, measured every 2 h with heat dissipation sensors, showed that soil drying was not affectd by VAM or P treatment.

584 (PS 2)

ACTIVE OSMOTIC ADJUSTMENT: EFFECT ON CHANGES IN SORBITOL AND OTHER CARBOHYDRATES IN LEAVES, ROOTS AND STEMS OF APPLE

Zhongchun Wang*, Bruno Quebedeaux, Jr. and Gary Stutte, Department of Horticulture, University of Maryland, College Park, MD 20742

Potted 'Jonathan' apple trees were subjected to water stress in a greenhouse. Midday leaf water potential ($\Psi_w$), osmotic potential ($\Psi_s$), and carbohydrates of various plant parts were measured to determine whether active osmotic adjustment occurred and its impact on carbohydrates. Mature leaves had the highest soluble sugar levels (74 mg/ml sap) and the lowest $\Psi_s$ (-1.85 MPa), followed by young leaves (-1.58), stems (-1.02), and roots (-0.87). Sorbitol (sor) concentrations in young leaves, stems, and roots were 57, 28, and 27% of that in mature leaves. The concentrations of sucrose (suc), glucose, and fructose in young leaves, however, were 27, 35, and 146% higher than that in mature leaves. When $\Psi_w$ decreased from -1.0 to -3.2 MPa, active adjustments of 0.3 MPa were observed in mature leaves, stems and roots while an adjustment of 1.0 MPa was detected in young leaves. As water stress developed, sor increased and suc and starch decreased in mature leaves and stems. In contrast, the roots had a significant increase in suc but a decrease in sor. Both suc and sor increased in young leaves under water stress. The physiological significance of carbohydrate changes in various tissues under water stress will be discussed.

585 (PS 2)

**POSSIBLE ROLE OF MANNITOL 1-OXIDOREDUCTASE IN CELERY SINK TISSUE**

Johan M. H. Stoop (*) and D. Mason Pharr, Dept. of Horticultural Sci. and Plant Physiology Program, NCSU, Box 7609, Raleigh, NC 27695

Mannitol represents a major carbon storage compound in celery petioles. Recently, a novel mannitol dehydrogenase was isolated from celeriac (*Apium graveolens* L. var. *rapaceum*) root tips and partially purified to a specific activity of 210 µmol/h/mg protein. This NAD-dependent enzyme catalyzes the oxidation of mannitol to mannose, not fructose, and this is uniquely different from the mannitol oxidation in lower organisms. Data are presented that show that the enzyme is also present in celery (*Apium graveolens* L. var. *dulce*) sink tissue. The product of the mannitol oxidation in celery was determined to be mannose. Previous studies suggested that differences in fertilizer concentration in the root zone of celery could alter carbon partitioning between mannitol and hexose sugars and change enzyme activities. In this study, plants were grown hydroponically at two different salt concentrations, E.C.=2.7 mS/cm and E.C.=6.0 mS/cm. A high mannitol to hexose ratio was observed in celery petioles of plants grown at high salt concentration, supporting the hypothesis that the salt environment might alter both mannitol and hexose pools in a coordinate way. Plants grown at both salt concentrations did not differ in root or shoot fresh weight. These data support the hypothesis that mannitol might be involved in osmoprotection by acting as a compatible solute. Mannitol accumulation in celery petioles might be, in part, regulated through a mannitol catabolizing pathway involving mannitol oxidation to mannose by the NAD-dependent 1-oxidoreductase, mannose phosphorylation by mannose kinase, mannose-6-P conversion to fructose-6-P by phosphomannose isomerase and further conversion to hexoses through a sucrose intermediate. The novel mannitol 1-oxidoreductase might therefore be a key enzyme in controlling mannitol levels in sink tissues.

586 (PS 2)

SOIL-ROOT INTERFACE WATER POTENTIAL IN *Prunus* X *cistena* GROWN IN DIFFERENT SOIL MIXES

Hui-lian Xu*[1], J. Caron[1], P. Y. Bernier[2] and A. Gosselin[1], 1 Horticulture Research Centre, Laval University, Quebec, Canada, G1K 7P4; 2 Research Station, Forestry Canada, Quebec, G1V 4C7

Water potential at soil-root interface ($WP_{s-r}$) appears to be a good indicator of soil water availability to the plants. However, it is not easy to measure it routinely. Plant water status is more convenient to manage from bulk soil water potential ($WP_{soil}$) determination if a good relationship between $WP_{soil}$ and $WP_{s-r}$ can be established. In order to elucidate this relationship in different substrates, three soil mixes: Mix-1) composted bark, peat, sand; Mix-2) peat, bark, sand, compost; and Mix-3) peat, sawdust, sand, were used with *Prunus* X *cistena*. Two-year-old field grown plants were placed in a greenhouse. After soil water was depleted to different levels, $WP_{soil}$, xylem water potential ($WP_{xylem}$), transpir-ation as well as stomatal conductance were measured using a portable gas exchange system. $WP_{s-r}$ was calculated from these measured data. Plants grown in Mix-2 kept higher $WP_{s-r}$ until $WP_{soil}$ decreased to -24 KPa, while $WP_{s-r}$ in the plants grown in Mix-1 began to decrease at -5 KPa of $WP_{soil}$. Mix-3 showed a medium critical $WP_{soil}$ for $WP_{s-r}$ to decrease. Since there was a better availab-ilty of soil water to the plants, plants in Mix-2 also showed higher $WP_{xylem}$. Dynamic analysis showed that plants in Mix-2 kept better plant water status mainly by avoiding water stress. Plants in Mix-3 also avoided water stress, but it was, at least in part, attributed to less leaf area

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587 (PS 2)

PHOTOSYNTHESIS, WATER RELATIONS AND GROWTH RESPONSES OF GREENHOUSE TOMATO PLANTS TO HIGH-SOLUTION ELECTRIC CONDUCTIVITY AND LOW SOIL WATER CONTENT: SOIL WATER DEFICIT ACCLIMATION AND SALT BUILD-UP EFFECT

Hui-lian Xu*, Laurent Gauthier and André Gosselin, Horticulture Research Centre, Laval University, Quebec, Canada, G1K 7P4.

Greenhouse tomato plants (cv. Capello) were grown in peat moss based substrate and treated with high and low nutrient solution electric conductivity (EC) under high (95±5%) and low (55±8%) soil water conditions. Photosynthesis (Pn) was decreased about 25% 1 day after soil water content reached 55%. However, as the soil water deficit was prolonged, the effect of water deficit diminished, with the decreasing extent of ca 15 % on the 11th and 16th days from starting treatments. This suggested that tomato plants acclimated to soil water deficit. One day after soil water content reached 55%, leaf turgor potential (TP) decreased largely as leaf water potential (WP) dropped. However, as soil water level was kept constant for a period, TP recovered to a quite large extent even at the same WP level. This TP recovery accounted for the photosynthetic recovery. Drying the constantly well watered plants to the same soil water level decreased Pn to a much larger extent than did the prolonged soil water deficit. This supports the above-mentioned photosynthetic acclimation. The effects of high EC were not observed 1 day after the treatments started, but became larger and larger as the treatments were prolonged. Build-up of EC in the soil accounted for this result.

588 (PS 2)

DIURNAL WATER RELATIONS OF PLUM EXPOSED TO DIFFERENT ATMOSPHERIC OZONE PARTIAL PRESSURES.

W.A. Retzlaff*, L.E. Williams, and T.M. DeJong, University of California Kearney Agricultural Center, Parlier, CA 93648 USA

Japanese plum (*Prunus salicina* Lindel., 'Casselman') trees were enclosed in open-top chambers on 1 May 1989 and exposed to three atmospheric ozone partial pressures (charcoal-filtered air [CF], ambient air [AA], and ambient air+ozone [AO]) during the growing season in 1989, 1990, 1991, and 1992. The mean 12-h (0800-1900 HR PDT) ozone partial pressures during 1992 were 0.027, 0.045, and 0.087 $\mu Pa\ Pa^{-1}$ in the CF, AA, and AO treatments, respectively. Both stem and leaf water potential ($\psi$) decreased from 0700 to 1600 HR PDT and were lowest at midday (1200-1400 HR PDT) in all ozone treatments. Leaf and stem $\psi$ were equivalent at predawn, but leaf $\psi$ was lower than stem $\psi$ during the diurnal period. Midday stem $\psi$ was greater in the AA and AO treatments compared to the CF treatment. Before 1 Aug., stomatal conductance of trees in the AO treatment was reduced compared to the CF treatment, but diurnal fluctuations were similar between the two treatments. Following 1 Aug., stomatal conductance of trees in the AO treatment was reduced compared to the CF treatment, but stomatal conductance of the AO treatment remained the same throughout the day. Trees in the AO treatment had greater leaf fall earlier in the growing season than those of the other treatments. Changes in plum tree stem $\psi$ under chronic ozone stress are probably due to a loss (early senescence) of transpiring leaf area as well as declines in stomatal conductance.

589 (PS 2)

EFFECT OF POTASSIUM AND DROUGHT STRESS ON GAS EXCHANGE, WATER RELATIONS AND WATER USE EFFICIENCY OF *HIBISCUS ROSA SINENSIS* L. cv. LEPRECHAUN

Jonathan N. Egilla*, F. T. Davies Jr., and T. W. Boutton, Department of Horticultural Sciences and Rangeland Ecology and Management, Texas A&M University, College Station, Texas 77843-2133

Rooted cuttings of *Hibiscus rosa sinensis* L. cv. Leprechaun were irrigated with full strength Hoaglands solution containing 0, 2.5, or 10 mM $K^+$. Half of the plants at each $K^+$ level were subjected to a 21-day slowly developing drought stress cycle (DS) followed by a recovery period (day 22), while the other half were non-drought stressed (NDS). Midday leaf water potential ($\Psi_{leaf}$) at day 21 were -1.5 to -1.6 MPa for DS and -0.5 MPa for NDS plants. Photosynthesis (A) was lowest during early stress and recovery of 0 mM $K^+$ plants. Transpiration (E), stomatal conductance (g), and instantaneous water use efficiency (A/E), were generally lowest in 0 mM $K^+$ plants. During peak stress, A was highest in the 2.5 mM $K^+$ plants, whereas E was lowest and A/E highest in 10 mM $K^+$ plants. $\Psi_{leaf}$ did not differ among $K^+$ treatments during peak stress and recovery, but osmotic potential was highest (least negative) and turgor potential lowest in 0 mM $K^+$ plants. DS plants had lower carbon isotope discrimination ($\Delta$) compared to NDS plants at all $K^+$ levels, suggesting higher A/E for DS plants. Although there was no significant $K^+$ effect, there was a trend at peak drought stress of a lower $\Delta$ and higher A at the 2.5 mM $K^+$ level.

590 (PS 2)

INFLUENCE OF POTASSIUM ON PLANT GROWTH AND $^{86}Rb^+$-LABELED LIVE ROOTS OF DROUGHT-STRESSED *HIBISCUS ROSA SINENSIS* L. cv. LEPRECHAUN

Jonathan N. Egilla*, F. T. Davies Jr., and M. C. Drew, Department of Horticultural Sciences, Texas A&M University, College Station, Texas 77843-2133

Rooted cuttings of *Hibiscus rosa sinensis* L. cv. Leprechaun were grown in fine sand and irrigated with full strength Hoaglands solution containing 0, 2.5, or 10 mM $K^+$. Half of the plants at each $K^+$ level were subjected to a 21-day slowly developing drought stress cycle (DS) and the other half were non-drought stressed (NDS), which yielded a midday leaf water potential ($\Psi_{leaf}$) at day 21 of -1.5 to -1.6 MPa and -0.5 MPa, respectively. Drought stress reduced leaf area (LA), leaf area ratio (LAR), shoot, root, leaf and total dry weights of 2.5 and 10 mM plants and increased the root:shoot ratio of all $K^+$ treatments. Increasing $K^+$, increased all growth parameters measured in both DS and NDS plants, except for LAR, which was greatest at 0 mM $K^+$. At 0 mM $K^+$, drought stress did not affect LA, LAR, shoot, root and total dry weights. Neither drought nor $K^+$ treatments affected specific leaf area (SLA). In NDS plants, $K^+$ had no effect on percent live root ratio (PLR) as indicated by translocation of $^{86}Rb^+$ from leaves into living roots, determined by autoradiography. Although drought stress reduced PLR at all $K^+$ levels, PLR was greatest at the higher $K^+$ levels.

591 (PS 2)

INFLUENCE OF MYCORRHIZAL FUNGI AND DROUGHT ACCLIMATION ON GROWTH AND DROUGHT RESISTANCE OF *ROSA HYBRIDA* cv. MEINEBLE

Sein Hla Bo* and Fred T. Davies, Jr., Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

During water stress, non-drought acclimated (NDA) rose plants had a lower leaf water potential, stomatal conductance (g), and net photosynthesis than drought acclimated (DA) plants. DA plants conserved water (lower g prior to water stress) which allowed for better maintenance of gas exchange and water relations than NDA plants during stress. Osmotic adjustment (lower $\Psi_\pi$) occurred in DA plants which allowed for greater turgor than NDA plants during stress. DA leaves had decreased leaf sucrose and total soluble carbohydrates. Mycorrhizal (VAM) plants colonized with *Glomus intraradices* had higher relative growth rates, net assimilation rates and water use efficiency than noncolonized (NVAM) plants, regardless of stress. Root growth was greater in VAM plants, but there were no differences in shoot mass, leaf area and macro-elements (P, N, K, Ca, Mg) with NVAM plants. DA-VAM plants had higher sucrose and total soluble carbohydrates than DA-NVAM plants. DA enhanced mycorrhizal colonization. Any mycorrhizal enhancement of plant water relations was not attributable to higher leaf P or confounded by differences in plant transpirational surface.

592 (PS 2)

EVALUATION OF WATER USE BY TWELVE SPECIES OF ORNAMENTAL GRASS IN A CONTROLLED ENVIRONMENT

June Wolfe III*, Jayne M. Zajicek and Mark A. Hussey, Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

Twelve species of native and introduced ornamental grasses were subjected to a drought treatment in a greenhouse. The objective of this study was to determine which species had the lowest water use and which were most aesthetically pleasing under water stress. Visual observations of progressive water stress were compared to instrumental measurements of water consumption, leaf water potential, stomatal resistance, and transpiration. Differences in water use were found between species when compared on a leaf area basis. The relationship between visual observations and plant water status was not consistent across species.

593 (PS 2)

CHANGES IN THE RESISTANCE TO WATER MOVEMENT THROUGH THE SOIL/PLANT PATHWAY IN SALINIZED SUNFLOWER (*HELIANTHUS ANNUUS* L. *GIGANTEUS*).

D.E. Balint*, J.M. Zajicek and M.C. Drew, Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

The water potential gradient through the plant and the resistance to the viscous flow of water are two properties that may be affected by salinity stress within a plant. In this study, sunflowers in sand culture were irrigated with various concentrations of NaCl up to 75 mM. The concentration of NaCl was gradually raised to avoid osmotic shock and the $Ca^{2+}$ concentration was maintained at 4.0 mM. Non-destructive techniques such as stem-flow gauges, psychrometers, porometry and weighing were used to determine changes in the resistance to flow and the pattern of

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water movement. Estimates of water potential were obtained for the rooting medium, the xylem at the shoot-root junction, and the upper leaves. From measurements of transpiration values, resistance to water flow across the roots, and between roots and leaves could be calculated. At 5 and 6 days of salinization, there were increases in the resistance to water flow across roots at the 75 mM salt level. This was accompanied by an increase in stomatal resistance to water vapor. These results suggest that moderate increases in salt level markedly affect the water relations of sunflower.

594 (PS 2)

BUFFALOGRASS SEEDLING SCREENING *IN VITRO* FOR NaCl TOLERANCE

Scott D. Reid*, Anthony J. Koski, and Harrison G. Hughes, Department of Horticulture, Colorado State University, Fort Collins, CO 80523

Buffalograss (*Buchloë dactyloides* [Nutt.] Engelm.) is adapted for use as a low maintenance turf in much of the semi-arid West. New cultivars with improved turf characteristics are being developed and released, but little information quantifying either relative tolerance or variability among germplasms to salt stress is available. An *in vitro* procedure was used to characterize seedling growth response to additions of 0-300 mol $m^{-3}$ NaCl in 50 mol $m^{-3}$ increments in media containing MS basal salts solidified with 0.6% agar. Germinated seeds of cultivars Sharp's Improved, Texoka, Topgun, and Plains transferred to treatments were evaluated after 40 d growth. The threshold for decline in shoot dry matter vs control was 50 mol $m^{-3}$ NaCl for all cultivars. An average 50% shoot dry matter reduction vs controls across cultivars was found at 150 mol $m^{-3}$ NaCl, affecting leaf length but not survival; shoot [$Na^+$] ranged from 9.12 - 9.86 mg $g^{-1}$ dry matter. Survival was severely affected at 250 mol $m^{-3}$ NaCl. Cv. x NaCl interaction was significant.

595 (PS 2)

**WATER CONSERVATION POTENTIAL OF NON-TURF GROUND COVERS VERSUS KENTUCKY BLUEGRASS UNDER INCREASING LEVELS OF DROUGHT STRESS.**

David Staats and James E. Klett*, Department of Horticulture, Colorado State University, Fort Collins, CO 80523.

In June 1991, a two yield field study was initiated to determine if three non-turf ground covers actually use less water than Kentucky Bluegrass (KBG). Irrigation treatments were based on percentages of ET (100%, 75%, 50%, 25%, 0%) and calculated by the modified Penman equation. Establishment rates, visual quality, soil moisture and canopy temperature were measured over two seasons. KBG sustained good appearance at irrigation rates as low as 50% ET. Potentilla tabernaemontani required irrigation rates between 50% and 75% of ET. It can be considered a low water user, but not a water conserving alternative to KBG. Cerastium tomentosum sustained good appearance at irrigation rates as low as 25% of ET. It can be considered a water conserving alternative to KBG but visual quality declined during seed formation. Sedum acre maintained good visual quality at irrigation rates as low as 25% of ET and is a water saving alternative to KBG.

596 (PS 2)

EFFECTS OF WATER DEFICIT ON CIRCADIAN PATTERNS OF ROOT WATER FLUX IN HONEY LOCUST

Patricia A. Taylor*, G.S. Premachandra and Robert J. Joly, Department of Horticulture, Purdue University, West Lafayette, IN 47907-1165

The volume flux of water ($J_V$) through roots of 2-month-old honey locust seedlings (*Gleditsia triacanthos* var. *inermis*) was estimated by using applied hydrostatic pressure. Shoots were severed 8 cm above the root collar, and root systems were mounted in the lid of a pressure chamber with the cut stump protruding through a gasket. The chamber, filled with Hoagland solution, was pressurized to 0.34 MPa, and exudate was delivered from each root system to an electronic balance via an automated system. $J_V$ was expressed on a fibrous-root dry weight basis and plotted over time for water-stressed seedlings and well-watered controls. A highly defined endogenous circadian rhythm in $J_V$ was observed, regardless of treatment, with maximal and minimal fluxes occurring at mid-day and midnight, respectively; the rhythm continued for up to 90 h. Seedlings subjected to water stress exhibited an approximately 4-fold reduction in $J_V$ at comparable points in the cycle. The severity of stress influenced both the amplitude and trajectory of the rhythm. Daily peaks of $J_V$ decreased gradually over a 3-day period in both moderately-stressed and well-watered plants. In contrast, peak $J_V$ from roots of severely-stressed plants increased by approximately 28% per day over the same time course. The electrical conductivity of the efflux also exhibited a highly defined rhythm which was phase-shifted from that of the $J_V$ rhythm by approximately 12 h.

597 (PS 2)

AN ASPIRATED RADIATION SHIELD FOR USE WITH THERMOCOUPLES IN AGRICULTURAL APPLICATIONS

K.T. Demchak*[1], G.M. Heisler[2], B.L. Goulart[1] and S.B. Gleason[3], [1]102 Tyson Bldg., University Park, PA 16802; [2]USDA Forest Service, NEFES - 5 Moon Library, Syracuse, NY 13210; [3]USDA Forest Service, NEFES - 301 Forest Resources Laboratory, University Park, PA 16802

Since air temperature measurements in agricultural applications are subject to radiation errors, aspirated radiation shields are used. Typically researchers employ a double-walled shield, but a simplified design has been developed that gives comparable results and was implemented in strawberry and raspberry trellis research. Components used to build one radiation shield were: one 7.6-cm fan, one 11.4-cm to 8.9-cm PVC reducer, one 8.9-cm to 3.8-cm reducer, two 25-cm sections of 3.8-cm PVC pipe, a ring of PVC (11.4-cm outside diameter, 7.6-cm inside diameter), one hose clamp, clear silicone sealant, and wire to connect the fan to an electricity supply. A reflective suface may be applied to enhance accuracy. The shield can be located at any height within a canopy and can be easily relocated by inserting the holder on which it is mounted into a 5.1-cm PVC pipe that has been imbedded in the ground. Experimental evidence revealed that either a DC or an AC power supply could be used, as long as noise distortion from the AC supply was integrated to 0 by choosing 60 Hz noise rejection as an option with the Campbell datalogger. With an AC fan, air flow over the sensor exceeds 6 m/s.

598 (PS 2)

EFFECTS OF DROUGHT STRESS ON PICLORAM UPTAKE, TRANSLOCATION AND EFFICACY IN RUSSIAN KNAPWEED (Centaurea repens L.)

R.G. Morrison*, N.K. Lownds and T.M. Sterling, Dept. of Agronomy & Horticulture and Dept. Entomology, Plant Path. and Weed Science, New Mexico State Univ., Las Cruces, NM 88003

Picloram uptake, translocation and efficacy were studied using greenhouse-grown Russian knapweed plants. $^{14}$C-picloram was applied as individual droplets to the adaxial surface and uptake and translocation following 24 or 96 hr quantified with liquid scintillation spectroscopy. For efficacy studies, whole plants were sprayed. Drought stress was induced by withholding water and subsequently irrigating plants at 40% of pot capacity. Drought stress was quantified using a pressure bomb. Picloram uptake into watered plants (-0.50 MPa) averaged 10% of applied and did not change under drought stress. Of the picloram absorbed, about 8% was translocated in watered plants with equal amounts acropetal and basipetal. Drought stress (-1.22 MPa or greater) reduced picloram translocation 50 to 75% and increased basipetal translocation to about 80% of the total translocated. Picloram efficacy, measured as plant mortality or reduction in fresh weight, was greater in watered plants.

599 (PS 2)

PRIMING AND ENVIRONMENTAL INFLUENCES ON GERMINATION OF TWO WOODY SPECIES

Gregory L. Davis*, David L. Hensley, and Steven C. Wiest, Department of Horticulture, Forestry, and Rec. Resources, Waters Hall, Kansas State University, Manhattan, KS. 66506

Osmoconditioning was examined as a presowing seed treatment for its influence on germination, rate of germination, and initial seedling root growth in seeds of *Amorpha fruticosa* L. (imbibed for 48 hrs) and *Hippophae rhamnoides* L. (imbibed for 18 hrs) at 25C. Based on preliminary studies, seeds were imbibed in one of five osmotic solutions (0, -0.2, -0.7, -1.5, or -3.0 MPa) prepared with polyethylene glycol-8000. Seeds were then sown in test tubes containing plugs of Oasis growing medium saturated with osmotic solutions of no drought (0 MPa) or drought (-1.0 MPa) conditions at 15-35C. Root growth was measured with an image analysis system. Total root growth per seedling was less for both species in drought conditions regardless of temperature. Presowing treatments did not produce large differences in germination or rate of germination in either species.

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600 (PS 2)

HYDRAULIC CONDUCTIVITY & EMBOLISMS IN SWEET CHERRY

Mark A. Hubbard*, James A. Flore, and Frank W. Ewers, Departments of Horticulture and Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824-1325, USA.

Percent loss of conductivity of sweet cherry (*Prunus avium* 'Emperor Frances') under dry conditions was determined by measuring hydraulic conductivity before and after high pressure perfusion removal of xylem embolisms. Cut stems were allowed to dry for 0 to 8 hours, recut underwater and the rate of flow of solution through the stems measured under positive pressure (~8.0 kPa). Hydraulic conductivity ($K_h$) was then calculated, and typical values for well hydrated stems were $6 \times 10^{-9}$ $m^4MPa^{-1}s^{-1}$. Embolisms were then dissolved by high pressure perfusion (125kPa) and the subsequent flow rate measured. A second $K_h$ was then calculated and the difference in $K_h$ values before and after the high pressure treatment used as a measure of % loss of conductivity (or % xylem embolism). A curve of the 'vulnerability' to xylem embolism was generated by plotting % loss of conductivity against initial stem water potential. The curve shows the stems undergo xylem embolism as soon as stem water potential reaches −1.5MPa, and at stem water potentials of −3 MPa, the stems are over 80% embolized. This cultivar appears to be vulnerable to embolism relative to other studied woody species, and xylem dysfunction likely is a problem early in a drying period. However, a particular rootstocks ability to supply water during a dry period and a cultivar's ability to limit water loss by stomatal closure will dictate the exact water potentials in the stem and thus its level of embolism.

601 (PS 2)

INCREASED ADH1 ACTIVITY IN GUAYULE CULTIVARS WITH ANAEROBIC STRESS TOLERANCE

Karen K. Oishi, Fu-Tai Chen and Dennis T. Ray*,Departments of Molecular and Cellular Biology, Pharmacology, and Plant Sciences, The University of Arizona, Tucson, AZ 85721.

In flood-intolerant species increased ADH1 activity is required to survive anaerobic stress. Guayule is a perennial shrub that grows well only in sandy well aerated soil. This study was conducted to determine the relative tolerance of three guayule cultivars, N565, N576 and 11605 to anaerobic stress, in comparison to the levels of induction of ADH1 activity. All three guayule cultivars had the same three ADH1 isoenzymes. Seedlings were anaerobically stressed for a maximum of 108 hr. N576 was the most tolerant to anaerobic stress and had the highest, 1860 IU/mg, and temporally the longest induction of ADH activity. N565 was the least tolerant to anaerobic stress and had the lowest, 400 IU/mg, and temporally the shortest induction ADH activity. N565 and 11605 had the same maximal induction of ADH activity and had many *Adh*1 DNA fragments in common. N576 had the least number of common *Adh*1 restriction fragments.

602 (PS 2)

**SEASONAL CHANGES ON THE QUALITY OF 'PERLETTE' TABLE GRAPES IN RESPONSE TO WATER-DEFICIT STRESS AT PARTICULAR STAGES OF DEVELOPMENT.**

Jorge Siller-Cepeda*, G. Osorio, M. Báez, E. Bringas, A. Sanchez and J. Avalos. C.I.A.D., A.C. and C.I.A.N.O., Apdo. Postal 1735, Hermosillo, Sonora. 83000 México. CIAD/DTAOV/RC/93/07.

The nature of yield and quality losses for many fruits is dependent upon the time when water deficits occur in relation to fruit development. We evaluated the water stress effect applied at different stages of development on the quality and harvest date of 'Perlette' table grapes. Nine treatments based on amount of water applied by the grower (100%, 80% and 60%) and their combinations at two growth stages, fruit set to véraison (F-V) and véraison to harvest (V-H) were compared. Weekly samples of fruit were analyzed for diameter, weight, volume, soluble solids, tritatable acidity, pH, and pectin content. Harvest percentage at each date was used as precocity index. Significant differences were found on diameter and weight among treatments at various stages of development. The earliest and highest harvest percentage was for (F-V 80% and V-H 100%) treatment. High °Brix were obtained when the water volume was reduced after véraision, but quality was poor. Chelator soluble pectins represented > 90% of total soluble pectins and was higher on the treatment (F-V 60% and V-H 60%) at harvest.

603 (PS 2)

CUTICULAR STRUCTURE IN MEXICAN REDBUD

Jimmy L. Tipton, Department of Plant Science, University of Arizona, Tucson, AZ 85721

Mexican redbud (*Cercis canadensis* var. *mexicana*) plants exhibit leaf phenotypes with either a thin, dull cuticle or a thick, glossy cuticle. We compared leaf and cuticular structure of greenhouse-grown Eastern redbud (*Cercis canadensis*) (ER), Dull Mexican redbud (DMR), and Glossy Mexican redbud (GMR) seedlings via scanning electron microscopy. Mexican redbud leaves were almost twice as thick as ER and had a multilayered palisade parenchyma common among arid land plants. Both the lower (adaxial) and upper (abaxial) cuticles of MR were significantly thicker than those of ER. The surface of the upper cuticle in ER and DMR was covered with blocky crystalline structures. The surface of the upper cuticle in GMR was smooth. There was no difference in lower cuticle thickness or leaf thickness between DMR and GMR. The upper cuticle of GMR was significantly thicker than that of DMR. Mature DMR and GMR growing in a landscape in El Paso, Texas, had similar characteristics. Detached leaves of ER lost water at a significantly greater rate than did either DMR or GMR. There was no significant difference in water loss rates by detached leaves of DMR and GMR.

604 (PS 2)

EFFECT OF SALINITY ON THE GROWTH AND COMPOSITION OF CUCUMBER FRUIT

Akio Tazuke, College of Agriculture, University of Osaka Prefecture, 593 Sakai, Osaka, Japan

Salinization of the nutrient solution with 60mM NaCl in spring caused severe growth inhibition of cucumber cv. 'Asomidori 5 Go' fruit which resulted in the formation of carrot-like shaped fruit. Growth activity of fruit was initially enhanced, then rapidly inhibited after 3 DAA. Growth inhibition of the fruit accompanied concomitant inhibition of the growth of ovules. In such fruits, marked changes in composition were observed including depletion of glucose and fructose, Na and Cl accumulation and Ca deficiency. Fruit firmness was markedly increased. Acid invertase activity of the fruit was enhanced by salinity. Sucrose synthase activity of the fruit was slightly reduced. These results seemed to suggest how translocation of assimilates, growth and sugar metabolism of fruit are altered by salinity.

605 (PS 2)

EFFECTS OF WATER STRESS ON *CATHARANTHUS ROSEUS*

Margaret Pinchbeck* and Richard J. McAvoy, Department of Plant Science, University of Connecticut, Storrs, CT 06269-4067

The leaves of many plant species exhibit a noticeable color change in response to water stress. A study was conducted to determine if physiological changes associated with imposed water stress could be correlated with quantifiable leaf color changes in *Catharanthus roseus*. The Minolta Chroma Meter CR-200 was used to measure leaf color changes during water stress in three cultivars of *Catharanthus*. In addition, soil and plant water content, osmotic pressure, net photosynthetic rate, transpiration rate, and stomatal conductance were determined. Two components of light, chroma and L value, showed a correlation to the water content of the plant tissue. As plant water content decreased, both chroma and L value decreased. Since a change in leaf color (or a component of color) is easily monitored, the Chroma Meter could ultimately be used to detect incipient water stress in greenhouse crops.

606 (PS 3)

DIURNAL PATTERN OF ADP-GLUCOSE PYROPHOSPHORYLASE ACTIVITY IN TOMATO

Sitheswary Logendra* and Harry W. Janes, Department of Plant Science, Rutgers University, New Brunswick, NJ 08903

The diurnal pattern of the activity of the starch synthesizing enzyme ADP-glucose Pyrophosphorylase was studied in young tomato seedlings, grown under a light/dark cycle of 12h/12h. The third leaf from the base of the plant was used for the study when they were 80 to 90% fully expanded. The enzyme activity had two peaks, a smaller peak during the light period and a larger peak during the dark period. The activity began to increase before the lights were turned on and it was maintained for the first four hours of the light period and then began to decline. Similarly, the activity began to increase again before the lights were turned off and remained high for the first four hours of the dark period.



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607 (PS 3)

PHOTOSYNTHETIC CAPACITY, PHOTOPERIOD, AND SHOOT ELONGATION OF HARDY EVERGREEN AZALEAS (RHODODENDRON) CULTIVARS

David J. Ballantyne*, Dept. of Biology, University of Victoria, Victoria, B.C., Canada V8W 2Y2

In a June-July greenhouse experiment photosynthetic capacity ($P_{cap}$) and shoot elongation were determined for 13 azalea cultivars. While the positive correlation between shoot elongation and $P_{cap}$ was relatively low, the 2 cultivars with the highest rate of shoot elongation ('Treasure' and 'Noordthiana') had the highest $P_{cap}$. In October-January greenhouse experiments, 'Treasure' and 'Noordthiana' had highest rates of shoot elongation, but only 'Treasure' had a high $P_{cap}$ and 'Noordthiana' had a very low $P_{cap}$. A growth chamber experiment showed that while long days stimulated shoot growth (compared to short days) they had no influence on $P_{cap}$. Gibberellin sprays stimulated shoot growth of 'Vuyk's Scarlet' in the greenhouse during June-July but had no effect on $P_{cap}$. During November-January in the greenhouse long days stimulated shoot growth and in both summer and winter periods production time of cultivars with a rapid rate of shoot elongation was considerably less than for slower-growing cultivars, although rates of shoot elongation were much slower during winter periods.

608 (PS 3)

**SOYBEAN GROWTH UNDER MICROWAVE-POWERED LAMPS, HIGH IRRADIANCE DISCHARGE LAMPS, OR SOLAR RADIATION, AT AMBIENT OR ELEVATED $CO_2$**

Steven J. Britz, Donald T. Krizek*, David R. Lee, William G. Harris, Wayne E. Hungerford, and William A. Bailey, Climate Stress Laboratory, NRI, ARS, U. S. Department of Agriculture, Beltsville, MD 20705-2350

Soybeans (Glycine max [L.] Merr. cv. Williams) were grown to a standard developmental stage (6th trifoliate leaf c. 50% fully expanded) in a sunlit, temperature-controlled greenhouse (27±3°C) or in growth chambers (27±1°C) under microwave-powered (MP) E lamps (Fusion Systems, Rockville, MD) or a 50-50 mixture of high pressure sodium and metal halide (HID) lamps. Daily PAR in growth chambers was 44 mol $m^{-2}$, provided either as a square-wave (HID; 875 µmol $m^{-2}$ $s^{-1}$) or in steps (MP; peak irradiance c. 1650 µmol $m^{-2}$ $s^{-1}$). Growth chamber experiments were conducted at 400 µl $l^{-1}$ or 700 µl $l^{-1}$ $CO_2$ ("ambient" or "elevated", respectively). Total dry matter was similar for all treatments at ambient $CO_2$ but MP-grown plants were more like greenhouse plants with respect to Leaf Area Ratio, Specific Leaf Weight, and length of stem and petiole. Axillary growth, however, was much less under greenhouse conditions. Elevated $CO_2$ resulted in a significant stimulation of plant growth under both HID and MP, but gains were greater under MP illumination. Enhanced growth of MP plants was marked by increased partitioning into roots. It is possible that morphological modifications in MP plants rendered them more efficient at conversion of PAR into dry matter.

609 (PS 3)

**USE OF MICROWAVE-POWERED LAMPS AS A NEW HIGH INTENSITY LIGHTING SOURCE IN PLANT GROWTH CHAMBERS: SPECTRAL CHARACTERISTICS**

Donald T. Krizek*, Roman M. Mirecki, Steven J. Britz, William G. Harris, and Richard W. Thimijan, Climate Stress Laboratory, NRI, ARS, U. S. Department of Agriculture, Beltsville, MD 20705-2350

The broad-band characteristics of microwave-powered E lamps (Fusion Systems Corp.) were determined in an EGC growth chamber with a water-cooled light cap and a plexiglass barrier. Radiation measurements were made from 0.29 to 3 µm with an Eppley PSP pyranometer and from 3 to 50 µm with an Eppley PIR pyrgeometer. Photosynthetic photon flux (PPF) was measured with a LI-COR quantum sensor. At full power, the lamps provided over 1700 µmol $m^{-2}$ $s^{-1}$ of PPF, 47.8 kW $m^{-2}$ from 0.29 to 3 µm, and 678 W $m^{-2}$ from 3 to 50 µm, and at half power, 650 µmol $m^{-2}$ $s^{-1}$ of PPF, 17.1 kW $m^{-2}$ from 0.29 to 3 µm, and 404 W $m^{-2}$ from 3 to 50 µm at a distance of 1.2 m. Spectral measurements were made every 2 nm from 250 to 792 nm with an Optronics Lab Model 752 spectroradiometer under a single bare lamp. Based on total irradiance between 250 and 792 nm, the distribution of irradiance from 250-280, 280-320, 320-400, 400-700, and 700-792 nm was 0, 0, 1.5, 88.1, and 10.5% for the E lamp and 0, 0.6, 7.8, 73.6, and 18.2% for a mid-day June sun at Beltsville, MD respectively. The phytochrome photoequilibrium for E lamps was calculated at 0.76 as compared to 0.72 for sunlight.

610 (PS 3)

**COMPARISON OF FOUR METHODS FOR ESTIMATING TOTAL LIGHT INTERCEPTION BY TREES OF VARYING FORMS.**

Jens N. Wünsche*, Alan N. Lakso, Terence L. Robinson, Steven S. Denning, Department of Horticultural Sciences, NY Agricultural Experiment Station, Geneva, NY 14456 and Instiute of Fruit and Vegetable Production, University of Bonn, D-5300 Bonn, Germany.

The objectives of this study were to: (1) compare four methods of estimating daily light interception (fisheye photography with image analysis, multiple light sensors, ceptometer and point grid) with various apple tree forms (Slender Spindle, Y- and T-trellises and vertical Palmette) and (2) evaluate the interaction of tree form, time of day and atmospheric conditions on light interception. All methods were highly correlated to each other ($R^2 \geq 92\%$) for estimated daily mean % total light interception by the various tree forms. Fisheye photography, ceptometer and sensor generated almost equal daily mean values of intercepted light by each tree form, whereas by using point grid values were slightly lower. Interactions of tree form, time of the day and diffuse/direct radiation on estimated light interception were found. Under overcast skies, daily variations in total light interception were small for all tree forms. Under clear skies, the time-of-day effect on light interception strongly increased from horizontal to vertical tree canopies, indicating the importance of multiple readings in upright canopies. All methods had advantages and disadvantages, but the good results obtained by using the rapid, inexpensive point grid method (counting of shaded points on sheet under canopy) on clear days may allow estimates of orchard light interception when other methods are too costly and/or time-consuming.

611 (PS 3)

INFLUENCE OF BORON NUTRITION ON PHOTOSYNTHESIS AND STOMATAL CONDUCTANCE OF OILSEED RAPE

Larry S. Kennedy*, Carl E. Sams, and Russell J. Lewis, Dept. Plant and Soil Science, The University of Tennessee, Knoxville, TN 37901

Rape (*Brassica napus* var. *oleifera*) plants were grown in a continually circulating hydroponic system with perlite as the root support medium. Two experiments (I and II) were supplied with complete nutrient solutions (modified Hoaglands) differing only in added boron ((I) 0.40 (normal), 0.20, or 0.04 mg $L^{-1}$, and (II) 0.40, 0.02, or <0.01 mg $L^{-1}$). A minimum of nine replications was examined in each experiment. Photosynthesis (Pn) and stomatal conductance (SC) readings were taken on leaves 8, 12, 16, 20, and 24 when the leaves attained 70% to 90% full expansion ((I) days 58, 76, 86, 97, 106 and (II) days 50, 70, 78, 88, and 97 respectively following planting dates). Measurements were taken at solar noon (± two hours) using a portable Pn analyzer (Analytical Development Company). Rape plants in experiment I appeared morphologically similar, did not exhibit B deficiency symptoms, and did not have significant Pn or SC. Morphological development of plants in experiment II varied widely among treatments. Photosynthesis and/or SC mean values were significantly reduced at leaf stages 16 to 24 as B availability decreased. Treatment contrasts within and between experiments suggest that the 0.02 to 0.04 mg $L^{-1}$ range of added B is critical for the development of normal Pn and SC in leaves. These findings support our previous research report that the natural ontogeny of oilseed rape is greatly affected within a narrow range of B availability.

612 (PS 3)

ASSIMILATE ACCUMULATION AND PARTITIONING IN PEPPER CULTIVARS DIFFERING IN SUSCEPTIBILITY TO STRESS-INDUCED ABSCISSION.

A.D. Turner and H.C. Wien, Dept. Fruit and Vegetable Science, Cornell University, Ithaca, N.Y. 14853.

Pepper cultivars differ in susceptibility to stress-induced bud abscission. The stress susceptible cultivar 'Shamrock' undergoes a larger reduction in net assimilation rate (NAR) under low light stress, and partitions less dry matter (DM) to reproductive structures than the more tolerant cultivar 'Ace'. To determine if photosynthetic rates under low light stress could explain NAR differences, photosynthesis was measured on 'Ace' and 'Shamrock'. Assimilate partitioning was compared through measurement of leaf and bud respiration rates and analysis of bud sugar concentrations. Cultivar photosynthetic rates of exposed leaves did not differ under low light. Bud respiration rates fell to a lower level in 'Shamrock' than 'Ace' in low light-stressed plants, while expanded leaves respired at higher rates in 'Shamrock' than 'Ace' under both full and low light. Bud sugar concentrations were significantly lower in 'Shamrock' than 'Ace' after 3 days of low light stress. Susceptibility to low light stress-induced bud abscission in 'Shamrock' appears to be associated with reduced assimilate partitioning to buds, perhaps caused by high assimilate consumption in maintenance of expanded leaves.

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587 (PS 2)

PHOTOSYNTHESIS, WATER RELATIONS AND GROWTH RESPONSES OF GREENHOUSE TOMATO PLANTS TO HIGH-SOLUTION ELECTRIC CONDUCTIVITY AND LOW SOIL WATER CONTENT: SOIL WATER DEFICIT ACCLIMATION AND SALT BUILD-UP EFFECT

Hui-lian Xu*, Laurent Gauthier and André Gosselin, Horticulture Research Centre, Laval University, Quebec, Canada, G1K 7P4.

Greenhouse tomato plants (cv. Capello) were grown in peat moss based substrate and treated with high and low nutrient solution electric conductivity (EC) under high (95±5%) and low (55±8%) soil water conditions. Photosynthesis (Pn) was decreased about 25% 1 day after soil water content reached 55%. However, as the soil water deficit was prolonged, the effect of water deficit diminished, with the decreasing extent of ca 15 % on the 11th and 16th days from starting treatments. This suggested that tomato plants acclimated to soil water deficit. One day after soil water content reached 55%, leaf turgor potential (TP) decreased largely as leaf water potential (WP) dropped. However, as soil water level was kept constant for a period, TP recovered to a quite large extent even at the same WP level. This TP recovery accounted for the photosynthetic recovery. Drying the constantly well watered plants to the same soil water level decreased Pn to a much larger extent than did the prolonged soil water deficit. This supports the above-mentioned photosynthetic acclimation. The effects of high EC were not observed 1 day after the treatments started, but became larger and larger as the treatments were prolonged. Build-up of EC in the soil accounted for this result.

588 (PS 2)

DIURNAL WATER RELATIONS OF PLUM EXPOSED TO DIFFERENT ATMOSPHERIC OZONE PARTIAL PRESSURES.

W.A. Retzlaff*, L.E. Williams, and T.M. DeJong, University of California Kearney Agricultural Center, Parlier, CA 93648 USA

Japanese plum (*Prunus salicina* Lindel., 'Casselman') trees were enclosed in open-top chambers on 1 May 1989 and exposed to three atmospheric ozone partial pressures (charcoal-filtered air [CF], ambient air [AA], and ambient air+ozone [AO]) during the growing season in 1989, 1990, 1991, and 1992. The mean 12-h (0800-1900 HR PDT) ozone partial pressures during 1992 were 0.027, 0.045, and 0.087 μPa $Pa^{-1}$ in the CF, AA, and AO treatments, respectively. Both stem and leaf water potential ($\psi$) decreased from 0700 to 1600 HR PDT and were lowest at midday (1200-1400 HR PDT) in all ozone treatments. Leaf and stem $\psi$ were equivalent at predawn, but leaf $\psi$ was lower than stem $\psi$ during the diurnal period. Midday stem $\psi$ was greater in the AA and AO treatments compared to the CF treatment. Before 1 Aug., stomatal conductance of trees in the AO treatment was reduced compared to the CF treatment, but diurnal fluctuations were similar between the two treatments. Following 1 Aug., stomatal conductance of trees in the AO treatment was reduced compared to the CF treatment, but stomatal conductance of the AO treatment remained the same throughout the day. Trees in the AO treatment had greater leaf fall earlier in the growing season than those of the other treatments. Changes in plum tree stem $\psi$ under chronic ozone stress are probably due to a loss (early senescence) of transpiring leaf area as well as declines in stomatal conductance.

589 (PS 2)

EFFECT OF POTASSIUM AND DROUGHT STRESS ON GAS EXCHANGE, WATER RELATIONS AND WATER USE EFFICIENCY OF *HIBISCUS ROSA SINENSIS* L. cv. LEPRECHAUN

Jonathan N. Egilla*, F. T. Davies Jr., and T. W. Boutton, Department of Horticultural Sciences and Rangeland Ecology and Management, Texas A&M University, College Station, Texas 77843-2133

Rooted cuttings of *Hibiscus rosa sinensis* L. cv. Leprechaun were irrigated with full strength Hoaglands solution containing 0, 2.5, or 10 mM $K^+$. Half of the plants at each $K^+$ level were subjected to a 21-day slowly developing drought stress cycle (DS) followed by a recovery period (day 22), while the other half were non-drought stressed (NDS). Midday leaf water potential ($\Psi_{leaf}$) at day 21 were -1.5 to -1.6 MPa for DS and -0.5 MPa for NDS plants. Photosynthesis (A) was lowest during early stress and recovery of 0 mM $K^+$ plants. Transpiration (E), stomatal conductance (g), and instantaneous water use efficiency (A/E), were generally lowest in 0 mM $K^+$ plants. During peak stress, A was highest in the 2.5 mM $K^+$ plants, whereas E was lowest and A/E highest in 10 mM $K^+$ plants. $\Psi_{leaf}$ did not differ among $K^+$ treatments during peak stress and recovery, but osmotic potential was highest (least negative) and turgor potential lowest in 0 mM $K^+$ plants. DS plants had lower carbon isotope discrimination ($\Delta$) compared to NDS plants at all $K^+$ levels, suggesting higher A/E for DS plants. Although there was no significant $K^+$ effect, there was a trend at peak drought stress of a lower $\Delta$ and higher A at the 2.5 mM $K^+$ level.

590 (PS 2)

INFLUENCE OF POTASSIUM ON PLANT GROWTH AND $^{86}Rb^+$-LABELED LIVE ROOTS OF DROUGHT-STRESSED *HIBISCUS ROSA SINENSIS* L. cv. LEPRECHAUN

Jonathan N. Egilla*, F. T. Davies Jr., and M. C. Drew, Department of Horticultural Sciences, Texas A&M University, College Station, Texas 77843-2133

Rooted cuttings of *Hibiscus rosa sinensis* L. cv. Leprechaun were grown in fine sand and irrigated with full strength Hoaglands solution containing 0, 2.5, or 10 mM $K^+$. Half of the plants at each $K^+$ level were subjected to a 21-day slowly developing drought stress cycle (DS) and the other half were non-drought stressed (NDS), which yielded a midday leaf water potential ($\Psi_{leaf}$) at day 21 of -1.5 to -1.6 MPa and -0.5 MPa, respectively. Drought stress reduced leaf area (LA), leaf area ratio (LAR), shoot, root, leaf and total dry weights of 2.5 and 10 mM plants and increased the root:shoot ratio of all $K^+$ treatments. Increasing $K^+$, increased all growth parameters measured in both DS and NDS plants, except for LAR, which was greatest at 0 mM $K^+$. At 0 mM $K^+$, drought stress did not affect LA, LAR, shoot, root and total dry weights. Neither drought nor $K^+$ treatments affected specific leaf area (SLA). In NDS plants, $K^+$ had no effect on percent live root ratio (PLR) as indicated by translocation of $^{86}Rb^+$ from leaves into living roots, determined by autoradiography. Although drought stress reduced PLR at all $K^+$ levels, PLR was greatest at the higher $K^+$ levels.

591 (PS 2)

INFLUENCE OF MYCORRHIZAL FUNGI AND DROUGHT ACCLIMATION ON GROWTH AND DROUGHT RESISTANCE OF *ROSA HYBRIDA* cv. MEINEBLE

Sein Hla Bo and Fred T. Davies, Jr., Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

During water stress, non-drought acclimated (NDA) rose plants had a lower leaf water potential, stomatal conductance (g), and net photosynthesis than drought acclimated (DA) plants. DA plants conserved water (lower g prior to water stress) which allowed for better maintenance of gas exchange and water relations than NDA plants during stress. Osmotic adjustment (lower $\Psi_\pi$) occurred in DA plants which allowed for greater turgor than NDA plants during stress. DA leaves had decreased leaf sucrose and total soluble carbohydrates. Mycorrhizal (VAM) plants colonized with *Glomus intraradices* had higher relative growth rates, net assimilation rates and water use efficiency than noncolonized (NVAM) plants, regardless of stress. Root growth was greater in VAM plants, but there were no differences in shoot mass, leaf area and macro-elements (P, N, K, Ca, Mg) with NVAM plants. DA-VAM plants had higher sucrose and total soluble carbohydrates than DA-NVAM plants. DA enhanced mycorrhizal colonization. Any mycorrhizal enhancement of plant water relations was not attributable to higher leaf P or confounded by differences in plant transpirational surface.

592 (PS 2)

EVALUATION OF WATER USE BY TWELVE SPECIES OF ORNAMENTAL GRASS IN A CONTROLLED ENVIRONMENT

June Wolfe III*, Jayne M. Zajicek and Mark A. Hussey, Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

Twelve species of native and introduced ornamental grasses were subjected to a drought treatment in a greenhouse. The objective of this study was to determine which species had the lowest water use and which were most aesthetically pleasing under water stress. Visual observations of progressive water stress were compared to instrumental measurements of water consumption, leaf water potential, stomatal resistance, and transpiration. Differences in water use were found between species when compared on a leaf area basis. The relationship between visual observations and plant water status was not consistent across species.

593 (PS 2)

CHANGES IN THE RESISTANCE TO WATER MOVEMENT THROUGH THE SOIL/PLANT PATHWAY IN SALINIZED SUNFLOWER (*HELIANTHUS ANNUUS* L. *GIGANTEUS*).

D.E. Balint*, J.M. Zajicek and M.C. Drew, Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

The water potential gradient through the plant and the resistance to the viscous flow of water are two properties that may be affected by salinity stress within a plant. In this study, sunflowers in sand culture were irrigated with various concentrations of NaCl up to 75 mM. The concentration of NaCl was gradually raised to avoid osmotic shock and the $Ca^{2+}$ concentration was maintained at 4.0 mM. Non-destructive techniques such as stem-flow gauges, psychrometers, porometry and weighing were used to determine changes in the resistance to flow and the pattern of



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575 (PS 1)

INFLUENCE OF POULTRY LITTER ON TOMATO YIELD, NUTRITION, AND SOIL CHEMISTRY

M. L. Baker*[1], D. R. Earhart[2], and V. A. Haby[2], Texas Agricultural Extension Service[1], Texas Agricultural Experiment Station[2], Overton, TX 75684

Composted poultry litter (PL) containing 2.98% N was hand-applied on individual plots in a RCB design with 3 replications. Rates (0, 8.2, and 16.3 $Mg \cdot ha^{-1}$) were based on N content of the PL and requirement for maximum tomato production. Comparisons were made with a fertilizer blend (FB) containing 558 $kg \cdot ha^{-1}$ of 14.1N-5.7P-9.2K applied in split application. 'Summer Flavor 5000' tomato plants were hand-planted 46 cm apart in rows spaced 3 m apart. Plant volume and average fruit weight were not influenced by any treatment. A 5920 $kg \cdot ha^{-1}$ yield increase was noted when PL rate was increased from 0 to 8.2 $Mg \cdot ha^{-1}$. Total yield was further increased 2757 $kg \cdot ha^{-1}$ by doubling the PL rate. Yields due to FB were lower but not significantly when compared to PL rates. This decrease in yield could possibly be attributed to FB lowering soil pH to borderline levels for production (5.7) while litter rates had little effect on pH. No differences in leaf P and K were measured. Both rates of PL decreased leaf Ca but increased Mg as rate increased. There was no difference in leaf N, P, K, Ca, or Mg when zero PL and FB were compared. FB increased soil $NO_3$-N in the 0- to 30-cm depth zone more than the PL treatments. When comparing the highest PL rate to the lowest, there was almost a one and one-half time increase in residual soil K at the 0- to 15-cm soil depth. PL increased soluble salts only in the 0- to 15-cm soil depth, however, levels were low.

576 (PS 1)

UTILIZING POULTRY LITTER AS A FERTILIZER: SWEET CORN YIELD, MINERAL NUTRITION, AND SOIL CHEMISTRY

D. R. Earhart*[1], V. A. Haby[1], and M. L. Baker[2], Texas Agricultural Experiment Station[1], Texas Agricultural Extension Service[2], Overton, TX 75684

Composted poultry litter (PL) containing 2.98% N was hand-applied to plots in a split-plot design with 3 replications. Application frequency (total, split) was the major plot and rate (0, 10.9, 21.7, and 43.6 $Mg \cdot ha^{-1}$) was the sub-plot. Rate was based on total N content of the PL and N requirement for maximum sweet corn production. Comparisons were made with a fertilizer blend (FB) containing 23.8N-4.3P-4.1K at a total rate of 564 $kg \cdot ha^{-1}$ in split applications. Leaf area and average ear weight of sweet corn ('Merit') were not affected by frequency or rate. Increasing PL rate from 10.9 $Mg \cdot ha^{-1}$ to 21.2 $Mg \cdot ha^{-1}$ increased yield by 3128 $kg \cdot ha^{-1}$. An increase to 43.6 $Mg \cdot ha^{-1}$ decreased yield which was probably due to an observed reduction in plant stand. When comparing FB with 10.9 $Mg \cdot ha^{-1}$ PL, the yields were equal. Plant P and K concentrations were increased linearly by PL rate. There were no differences in % N or $mg \cdot kg^{-1}$ Ca and Mg. The highest soil $NO_3$-N concentrations in the 15- to 30-cm depth range were produced by 43.6 $Mg \cdot ha^{-1}$ PL (15 $mg \cdot kg^{-1}$) and FB (35 $mg \cdot kg^{-1}$). Only the high litter rate increased soil $NO_3$-N below 30 cm. As PL rate increased, there was a corresponding increase in soil P. There was a linear increase in soil K from 60 to 200 $mg \cdot kg^{-1}$ as rate increased. A linear decrease in pH was noted when PL rate increased. Soil EC was almost 2 times higher in the 43.6 $Mg \cdot ha^{-1}$ PL plots than the next highest rate (275 vs. 150 $umhos \cdot cm^{-1}$).

577 (PS 1)

CILANTRO AND DILL RESPONSE TO NITROGEN FERTILIZER RATES

Muddappa Rangappa*, Harbans L. Bhardwaj, Ali I. Mohamed, and Anwar A. Hamama. Agricultural Research Station, Virginia State University, Petersburg, VA 23806

Two separate experiments were conducted during 1992 to determine optimum rate of nitrogen fertilizer for cilantro (Coriandrum sativum L.) and dill (Antheum graveolens L.) production in Virginia. Three varieties of cilantro and two varieties of dill were used. The experiments were planted on July 28 and August 26 with three nitrogen rates (100, 200, and 300 kg/ha) and fresh weights (30cm row length from each plot) were recorded periodically during the vegetative growth. Generally, the nitrogen did not affect the yield indicating that soil nitrogen plus 100 kg of applied nitrogen per hectare was adequate for optimum growth of both cilantro and dill. At 45 days after planting (DAP), C1410 had the highest fresh yield of 1.8 kg/m whereas at 66 DAP the highest yielding variety was 18135 in both plantings (7.1 and 3.1 kg/m, respectively for first and second plantings). The differences between dill varieties were non-significant except with the second planting where Bouquet significantly outyielded Dukat at 70 DAP. The analyses to determine effects of varieties, nitrogen rates, and plant age on chemical properties of cilantro and dill is continuing and will be presented.

578 (PS 1)

$C_3$ AND $C_4$ PLANT RESPONSES TO PHOSPHORUS-LIMITING ENVIRONMENTS

Marilou Halsted*, and Jonathan Lynch, Department of Horticulture, The Pennsylvania State University, University Park, PA, 16802

The anatomical and biochemical characteristics of $C_4$ plants may make them more efficient than $C_3$ plants in nutrient deficient environments. A greenhouse pot study was conducted in the summer of 1992 to compare the responses of six $C_3$, four $C_4$ and two $C_3$-$C_4$ intermediate species to three levels of phosphorus nutrition: adequate, deficient, and severely deficient. Severely deficient P nutrition reduced shoot weight by 74% and 85% on average in the $C_3$ and $C_4$ species, respectively. $C_3$ plants appear to be more efficient than the $C_4$ in producing shoot biomass under stressful P conditions and two genera having $C_3$, $C_4$ and $C_3$-$C_4$ intermediate species exhibited a trend in the order of $C_4$(least efficient) $C_3$-$C_4$ intermediate, $C_3$(most efficient). P nutrition was more significant than species or plant type in determining both the concentration of P in plant tissues and the carbon dioxide exchange rate (CER). A more detailed study is underway to compare biomass partitioning and P allocation schemes of these $C_3$ and $C_4$ and $C_3$-$C_4$ intermediate type plants.

579 (PS 1)

COMPARISON OF THREE BONEMEAL PRODUCTS ON GROWTH OF 'PILGRIM' TOMATO

Kimberly A Klock* and Henry G. Taber, Horticulture Dept. Iowa State University, Ames, IA 50011

Three commercially available bone meal products, meat and bone meal, steamed bone meal, and bone chips were compared with Ca $(H_2PO_4) \bullet H_2O$ for their effectiveness in phosphorous availability. These products were added to a soil media (20 soil: 40 peat: 40 perlite by volume) at rates to give 0, 50, 100, 200, and 400 mg $P \bullet kg^{-1}$. Products effectiveness was evaluated by growth and P uptake of 'Pilgrim' tomato (Lycoperisicon esculatum Mill.). Difference in plant dry weights among the products were significant at $P \leq 0.02$, with the greatest difference occurring between the control & the bone meal products. Differences were also evident among the products with respect to shoot P content (mg $P \bullet shoot^{-1}$). A significant interaction between product & rate was observed for foliar P concentration, but not shoot P content reflecting a growth dilution effect. Therefore, the three bone meal products were equally effective in providing P for optimum tomato growth.

580 (PS 2)

**LIGHT INTENSITY AND DROUGHT AS PREDISPOSITION FACTORS FOR DOGWOOD ANTHRACNOSE**

Dan Erbaugh*, Mark Windham, Ann Stodola and Robert Augé, Dept. of Ornamental Horticulture, P.O. Box 1071, University of Tennessee, Knoxville, TN 37901-1071

Environmental factors regulating spread of dogwood anthracnose remain largely unstudied, so we conducted a two-year experiment to determine if light intensity or drought can affect this disease. After leaf emergence in 1990, two-year-old potted dogwood trees (*Cornus florida* L.) were placed outdoors in shade huts giving light treatments of 100%, 50%, 10% or 2% ambient light. One year later, trees were removed from huts to inoculate them (artificially or naturally) with *Discula destructiva* Redlin sp. Nov. After inoculation, trees were returned to their former light treatments and some of the trees were subjected to drought. Disease progression, quantified as increasing percentage of leaves with lesions, was unaffected by inoculation procedure. Light did affect the disease; by the end of the experiment, disease percentages in well-watered trees were 30% at 10% light, 15% at 2% light and below 5% at 100% and at 50% light. Drought increased disease progression on all shaded trees, ultimately 8x at 50% light, 1.4x at 10% light and 2x at 2% light.

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OBGA's gardens and conservatories.

Additionally, the labels feature the common name engraved in Braille at the bottom of the label to facilitate education of visually impaired students and visitors. In anticipation of streamlining data collection on a plant's growth, flowering, fruiting, etc., each label also includes a barcode representation of the plant's accession number.

634 (PS 3)

CHOPPED NEWSPAPER FOR WEED CONTROL IN ORNAMENTALS

Norman Pellett* and David Heleba, Dept. of Plant and Soil Science, University of Vermont, Burlington, VT 05405

Chopped newspaper was applied at 15 and 25 cm depths around field rows of Gaillardia, Physostegia, and Daphne. The paper was held in placed by wetting, then rolling, or by a commercial binder used for hydroseeding. Both methods of holding paper in place were successful. All newspaper treatments controlled weeds very well. Fifteen cm paper depth resulted in higher weed count in September than 25 cm depth. Paper mulch held up well through the growing season and had little impact on crop growth.

635 (PS 3)

STIMULATING BUD BREAK AND IMPROVING OVERWINTER SURVIVAL IN ROOTED SOFTWOOD CUTTINGS.

Anna Perkins and Nina Bassuk, Dept. of Floriculture and Ornamental Horticulture, Cornell University, Ithaca, New York 14853, USA

The objectives of this research were to stimulate and accelerate new growth in rooted cuttings of difficult-to-root woody plants, thereby increasing overwinter survival rates in the first propagation year. Etiolated and non-etiolated cuttings were taken from field grown stock plants of Acer rubrum 'October Glory', Hamamelis vernalis, Hamamelis virginiana, and Stewartia pseudocamellia. After a 4 week etiolation period, during which the bases of new shoots were covered in black velcro bands, cuttings were taken in June, 1992 and dipped in one of three levels of IBA: 500, 1,000 , 5,000 ppm for A. rubrum 'October Glory', A. rubrum 'Red Sunset', and H. vernalis, and 1,000, 5,000 and 10,000 ppm for H. virginiana and S. pseudocamellia. After 3 to 8 weeks under mist, successfully rooted plants were given 16 hour days with 70/60 F. D/N greenhouse temperatures. Plants were treated with a foliar spray of thidiazuron 50 mg/L, thidiazuron followed by GA 4/7 250 mg/L ten days later, silver thiosulfite (STS) 1%, or STS followed by GA4/7 ten days later. Both STS and thidiazuron stimulated bud break in plants. After 4 weeks, plants were assessed for bud break, after which dormancy was induced under short days and cool temperatures (50/40 F. D/N). Once dormant, the plants' total growth and total nonstructural carbohydrates were measured, and plants were stored in 38 F. coolers for 3 months. At the end of 3 months, the plants were assessed for overwinter survival.

636 (PS 3)

ABSORPTION, TRANSLOCATION, AND METABOLISM OF DITHIOPYR IN SELECTED WEED SPECIES.

Nanik Setyowati* and Leslie A. Weston, Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington, KY 40546.

Field studies have shown that dithiopyr has potential as a herbicide in ornamental nursery crops. Previous work has shown that certain weeds differed considerably in their tolerance to dithiopyr, both in the field and in the greenhouse. Four weeds were selected on the basis of these studies; large crabgrass and velvetleaf, both susceptible, and barnyardgrass and ivyleaf morningglory, tolerant species.

Root uptake was assessed in these four species by treating seedlings with 0.5$\mu$Ci of $^{14}$C-labelled dithiopyr dissolved in half strength Hoaglands solution. Whole plants were sampled at 12, 24, 48 and 96 hour after treatment (HAT) and plants were separated into roots and shoots. Dithiopyr levels and polar metabolites were measured after methanolic extraction of plant parts. Insoluble $^{14}$C levels were measured after biological oxidation. At 12 HAT, TLC and HPLC separation of extracts showed no detectable metabolites of dithiopyr. By 24 HAT, two polar metabolites were detected in both root and shoot extracts of all species. Total $^{14}$C and polar metabolites increased in roots and shoots over time. Species differences in total $^{14}$C uptake and metabolism were noted, potentially contributing to dithiopyr selectivity differences.

637 (PS 4)

SPORE VIABILITY AND GERMINATION OF THE ENDANGERED ALEUTIAN SHIELD-FERN, *POLYSTICHUM ALEUTICUM*

Patricia S. Holloway* and David J. Boyd, Department of Plant, Animal and Soil Sciences, 309 O'Neill Resources Building, University of Alaska Fairbanks, Fairbanks, Alaska 99775.

Research was initiated in 1990 to study spore viability, spore germination *in vitro*, and methods of controlled environment culture for the endangered Aleutian shield-fern, *Polystichum aleuticum*. Examination of spores using scanning electron microscopy revealed from 24% to 78% deformed and possibly nonviable spores per plant. Normal spores germinated in 30-45 days on both Knop's solution and Hoagland's No 2 solution in aseptic culture. Germination was most rapid on cultures with less than 6 g/l agar. Cultures with no agar were susceptible to contamination by algae, and sporophyte losses during transfer to greenhouse media were high. Germination rate and subsequent appearance of the first leaf stage did not differ significantly within a medium pH range of 4.7 to 7.0. Spores exhibited a thermodormancy at 25°C, but germinated well at 18°C and required light for germination. Sporophyte transfer from aseptic culture was most successful after true fronds beyond the first leaf stage had developed. A commercial bedding plant mix composed of *Sphagnum* sp. peat and perlite provided an optimum rooting medium for the ferns.

638 (PS 4)

MICROPROPAGATION OF 'GERMAN RED' CARNATION (*DIANTHUS CARYOPHYLLUS*) FROM NODAL EXPLANTS

Tim D. Davis,* N. Sankhla, D. Sankhla, S.W. George, and J.M. Parsons, Texas A&M Univ. Res. & Ext. Ctr., 17360 Coit Rd., Dallas, TX 75252

Nodal explants were taken from both vegetative and flowering shoots of 'German Red' carnation and placed on MS medium supplemented with 2.0 mg/L benzylaminopurine (BAP) and 0.5 mg/L naphthaleneacetic acid. The explants taken from flowering shoots invariably produced flower buds *in vitro* and were of no value for micropropagation. With the vegetative explants, microshoots were observed after about 15 days. These were subcultured and the effect of cytokinins (kinetin, BAP, thidiazuron [TDZ]) on subsequent shoot production was evaluated. The cytokinins increased the number of shoots formed with TDZ and kinetin being the most and least effective, respectively. Shoots produced *in vitro* were rooted with 100% success *in vitro* or *ex vitro*. About 98% of the plants rooted *in vitro* or *ex vitro* survived transfer to the greenhouse and were successfully transplanted outdoors. In summary, starting from explants, well-branched flowering plants can be obtained in as little as 5-6 months. These results suggest that *in vitro* mass propagation of 'German Red' carnation is feasible.

639 (PS 4)

IMPROVING SEED GERMINATION OF *AQUILEGIA CHRYSANTHA* BY TEMPERATURE MANIPULATION

Tim D. Davis*, D. Sankhla, N. Sankhla, A. Upadhyaya, J.M. Parsons, and S.W. George, Texas A&M University Research & Extension Center, 17360 Coit Rd., Dallas, TX 75252

Seeds of *Aquilegia chrysantha* Gray were germinated under a variety of temperature regimes. Germination was nearly 90% under a day/night temperature regime of 25/20C but was reduced to 40% or less under constant 25C or a 25/10C day/night temperature regime. At day temperatures between 25 and 29C (night temperature = 20C), germination percentage dropped gradually to about 60% with increasing temperature. Above a day temperature of 29C, germination declined dramatically such that no germination occurred at 31C. Neither kinetin (1-10 mg/liter) nor ethephon (1-30 mg/liter) were able to reverse the inhibitory effects of a 33C day temperature. Our results indicate that seed germination of *A. chrysantha* is quite sensitive to temperature and that germination percentages of 75% or greater can be obtained under a 25-27C day/20C night temperature regime.

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562 (PS 1)

ANATOMICAL INVESTIGATION OF ESSENTIAL OIL GLANDS AND THIER DISTRIBUTION IN *OCIMUM BASILICUM* VARIETIES

C.L. Flinn*, R. Murray and J.E. Simon, Department of Horticulture, Purdue University, West Lafayette, IN 47907

Methyl cinnamate and citral, compounds used in large quantities by perfume and flavoring industries, are the major constituents of essential oils found in certain basil varieties. The composition and quantity of oil, sequestered in as many as 16 different types of glandular structures, however, has been shown to change over time with plant development. In this study, we used scanning electron microscopy to characterize glands associated with leaves and flower parts of 3 lines of *Ocimum basilicum*, 2 with a high percentage of metyl cinnamate and one with high citral (as rel. percent of total oil). Density and distribution of oil producing glands were visualized with a tissue printing method on adaxial and abaxial leaf surfaces of young, mature, and post-mature leaves. Scanning electron micrographs revealed the morphology of six types of glandular structures. Density of oil-producing glands decreased with leaf expansion. The tissue printing method allowed for rapid visualization of oil-containing glands. The density of resulting prints will be easily quantified with computer image analysis.

563 (PS 1)

SuperSorb-C AS A GROWTH MATRIX FOR $Ca^{2+}$ NUTRITION STUDIES OF DARK-GROWN SEEDLINGS

Patricia N. Myers*, James W. Cutler, and Cary A. Mitchell, Purdue University, Center for Plant Environmental Stress Physiology, West Lafayette, IN 47907-1165

SuperSorb-C (Aquatrols, Inc., Cherry Hill, NJ) has been used as a soil amendment in the horticultural industry for its tremendous water-holding capacity. However, the addition of nutrients to the medium, especially bivalent cations, greatly diminishes the ability of the copolymer acrylamide acrylate to absorb water. This study investigated the use of SuperSorb-C as the sole growth matrix for physiological investigations of hypocotyl elongation. Soybean seedlings were grown in a darkroom at varied levels of $Ca^{2+}$. Increased $Ca(NO_3)_2$ in the absorbing solution of the SuperSorb-C from 1 to 10 mM decreased the water-holding capacity of the copolymer from 96 ml $g^{-1}$ to 46 ml $g^{-1}$. The water potential of the medium was high for all $Ca^{2+}$ concentrations, ranging from -0.02 to -0.12 MPa. The average elongation rate of dark-grown soybean seedlings over a 54 h period increased from 0.9 to 1.1 to 1.4 mm $hr^{-1}$ with 1.0, 2.5, or 5.0 mM $Ca^{2+}$, respectively, then declined slightly with further increases in $Ca^{2+}$. The increased elongation rate was correlated with increased root development. SuperSorb has potential as a significant tool in the physiological studies of nutrient effects on plant growth and stress responses.

This project was supported in part by NASA grant NAG10-0093.

564 (PS 1)

YIELD CHARACTERISTICS OF A RICE CULTIVAR GROWN IN HYDROPONICS USING OPTIMIZED NUTRITIONAL REGIMES

Gayle M. Volk* and Cary A. Mitchell, NASA Specialized Center of Research and Training in Bioregenerative Life Support, Purdue University, West Lafayette, IN 47907-1165.

High yields and harvest indices in greenhouse studies indicated that japonica rice cultivar Ai-nan-tsao should be considered for inclusion in NASA's Controlled Ecological Life-Support Systems program. Ai-nan-tsao achieved a yield rate of 12.87 g $m^{-2}$ $d^{-1}$ when grown in continuously recirculating hydroponic systems under 12-h photoperiods in a growth chamber. Hydroponic systems have been improved such that contained plants have enhanced root development and a decreased edge effect. The total harvest index was 27% while shoot harvest index was 29%. A planting density of 775 plants m-2 resulted in an average of 5 tillers (and therefore 5 panicles) per plant. Average panicle weight was 1.5 g. Currently, various levels of nitrogen in the nutrient solution are being evaluated to attempt to shorten the life cycle and increase the harvest index. Nutritional analyses of the grain and inedible portions of the plants will identify changes in grain composition with respect to nutritional treatments relative to greenhouse soil culture. This project was supported in part by NASA grant NAGW2329.

565 (PS 1)

VEGETATIVE GROWTH OF POTATO UNDER SON AGRO HIGH-PRESSURE SODIUM, HIGH-PRESSURE SODIUM, AND METAL HALIDE LAMPS

N.C. Yorio*, C.L. Mackowiak, R.M. Wheeler, and J.C. Sager, The Bionetics Corp. (clm,ncy) and NASA Biomedical Operations and Research Office (rmw,jcs), Kennedy Space Center, FL 32899

The vegetative growth of potato (Solanum tuberosum L.) cvs. Norland (NL) and Denali (DN) was investigated comparing SON-AGRO high-pressure sodium (HPS-S), standard high-pressure sodium (HPS), and metal halide (MH) lamps. Plants were initiated from nodal culture and grown hydroponically in a reach-in growth chamber for 35 d with a 12-hr light/12-hr dark photoperiod and corresponding thermoperiod of 20/16 C. PPF for each treatment was maintained at 300 $\mu$mol $m^{-2}$ $s^{-1}$ and $CO_2$ levels maintained at 1000 $\mu$mol $mol^{-1}$ to promote growth. Results showed that main stem length (SL) and number of internodes (INT) for DN were significantly higher under HPS compared to MH, while HPS-S was not significantly different from the other lamp types. Total dry weight (TDW) of NL plants was significantly higher for HPS than for either HPS-S and MH, however there was no significant difference in SL and INT among lamp types. The data suggest that the 12.6% increase in blue light (400-500 nm) with HPS-S in comparison to conventional HPS lamps may not be sufficient to consistently decrease the stem elongation effects commonly seen with plants grown under HPS.

566 (PS 1)

ION ACCUMULATION IN PERICARP AND ENDOCARP OF CUCUMBER FRUIT AS INFLUENCED BY XYLEM AND PHLOEM IMPORT

Irvin E. Widders, Department of Horticulture, Michigan State University, East Lansing, MI 48824

Ion concentrations in pericarp tissue, 3.2% $K^+$, 0.9% $Ca^{2+}$, 0.57% $Cl^-$, 550 ppm $NO_3^-$-N, 0.51% $PO_4^{3-}$-P and 1.2% $SO_4^{2-}$-S on a dry wt basis, differed from that in endocarp tissue, 4.1%, 0.3%, 0.46%, 96 ppm, 0.72% and 1.3%, respectively, in 5 cm diam. cucumber fruit. Controlled environment experiments tested the hypothesis that xylem and phloem differentially supply pericarp and endocarp tissues with nutrients. Application of 6 mM Ca $(NO_3)_2$ during fruit development resulted in the pericarp having higher contents of $Ca^{2+}$ and $NO_3^-$ but not the endocarp. Shade (50% full sunlight) caused $Cl^-$ and $NO_3^-$ contents to decrease in both tissue. It was determined that xylem import could account for 73% and 100% of the total $Ca^{2+}$ in pericarp and endocarp, respectively, but only approximately 19% and 8% of the $K^+$. The role of xylem and phloem in supplying nutrients to developing cucumber fruits, as related to differences in transport of various ions within these two vascular systems, will be discussed.

567 (PS 1)

ROOT ZONE CUPRIC HYDROXIDE TREATMENT ENHANCES SUBSEQUENT GROWTH OF TOMATO, BUT NOT PEPPER, TRANSPLANTS

Joyce G. Latimer*, Department of Horticulture, Univ. of Georgia, Georgia Experiment Station, Griffin, GA 30223

'Sunny' tomato (Lycopersicon esculentum Mill.) and 'Jupiter' pepper (Capsicum annuum L.) seeds were sown in TODD 100A flats (Speedling, Inc.) treated with 100 g/liter cupric hydroxide applied to the root cell surfaces in a latex based carrier (Spin Out, Griffin Corp., Valdosta GA). Total root numbers were not affected by cupric hydroxide but initial root dry weight of 33-day-old tomato plants was reduced 30% by the treatment. Two-weeks after transplanting to sand-culture in the greenhouse, total root dry weight of treated transplants was 4% greater than that of untreated tomato transplants. The rate of shoot dry weight gain of treated transplants over 12 days of sand culture was slightly greater than that of untreated transplants. However, roots of 45-day-old pepper transplants were slower to recover from the copper damage. Initial root dry weight of treated plants was reduced 32% relative to controls. After two weeks of sand culture, root dry weight of treated plants was still 22% less than controls. Shoot growth of pepper transplants was unaffected. Root development inside the plug was particularly lacking indicating reductions in lateral root branching.

568 (PS 1)

EFFECT OF pH ON ROOT GROWTH OF SIX CULTIVARS OF WATERMELON

Aimin Liu[1], Joyce G. Latimer[1] and Robert E. Wilkinson[2]
[1]Dept. of Horticulture, [2]Dept. of Agronomy, Georgia Experiment Station, The University of Georgia, Griffin, GA 30223-1797

Watermelon [Citrullus lenatus (Thumb) Matsum and Nakai] cultivars Charleston Gray(CG), Crimson Sweet(CS), Dixielee(DL), Jubilee(JL), Mirage(MG) and Starbrite(SB) were grown in white quartz flintshot sand and watered daily with 0.01M sodium acetate buffer at pH 4.0, 4.5, 5.0, 5.5, 6.0, or 6.5. After two weeks, stem length, leaf area, leaf and root dry weight, and root number were measured. Nnumber of root decreased with decreasing pH below pH 5.0 in all cultivars except CG, which had an increase trend. Root number of MG and SB had negative linear and quadratic correlations respectively, with decreasing pH. In all cultivars, root dry weight increased with decreasing pH below pH 5.5. Under pH≤4.5, all cultivars except CG, had short or no tap root and thickened lateral roots. CG had a



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and increased apical necrosis. UV-$B_{BE}$ treatment increased lipid peroxidation after 24 h based on malondialdehyde (MDA) determination, but thereafter had no consistent effect on MDA. UV-$B_{BE}$ exposure slightly decreased the monogalactosyldiacylglycerol/digalactosyldiacylglycerol ratio during the initial 24 h, showing an effect on chloroplast membranes.

647 (PS 4)

ADVENTITIOUS SHOOT REGENERATION FROM IN VITRO-CULTURED LEAVES OF *RUBUS* GENOTYPES

Barbara Turk[1]*, Harry J. Swartz[2] and Richard H. Zimmerman[1], [1]USDA-ARS-Fruit Laboratory, Beltsville, MD 20705 and [2]Dept. of Horticulture, University of Maryland, College Park, MD 20742.

Regeneration of adventitious shoots from in vitro-derived leaves of several *Rubus* genotypes was tested with various concentrations of cytokinins and auxins, different basal media, duration of dark incubation periods, temperatures and photosynthetic photon fluxes (PPF). Thidiazuron (TDZ) was significantly more effective than benzyladenine (BA), and indolebutyric acid (IBA) more effective than naphthaleneacetic acid (NAA). Leaves of 'Summit' and 'Sentry' raspberries and MD-ETCE-1 blackberry were most responsive (percentage of leaves responding, number of shoots formed) to 1 $\mu$M or 10 $\mu$M TDZ plus 0.5 $\mu$M or 1 $\mu$M IBA; MD-ETCE-1 leaves did not respond to BA or TDZ with either 2.7 or 5.4 $\mu$M NAA. More organogenesis occurred on MS than on half-strength MS, Anderson modified, WPM or N6 media. For the five cultivars tested ('Autumn Bliss', 'Canby', 'Sentry', 'Summit', MD-ETCE-1), the most shoots formed when leaves were incubated at 20°C (vs. 25°C) for 1 week in the dark before they were exposed for 16 h per day to a PPF of 40 $\mu$mol·m$^{-2}$·s$^{-1}$. Significant differences in regeneration frequency were observed among four cultivars with the highest 71% for 'Autumn Bliss' and the lowest 29% for 'Summit'.

648 (PS 4)

PARTICLE BOMBARDMENT OF APPLE LEAF EXPLANTS INFLUENCES REGENERATION OF APPLE PLANTLETS

Petya Gercheva, R.H. Zimmerman, L.D. Owens, Christine Berry and F.A. Hammerschlag*, USDA/ARS, Beltsville, MD 20705-2350

Particle bombardment has been shown to be useful for genetic manipulation of many plants; however, a critical component for successful transformation is the ability of transformed cells to regenerate plants. This study describes factors that affect the regeneration efficiency of apple leaf explants following particle bombardment. Basal leaf segments of micropropagated 'Royal Gala' apple were treated with 1 µm gold particles (0.5 µg/10 µl), accelerated at either 4.5, 6.2, 7.6, 9.3 or 13.8 MPa, and cultured on N6 salts + 10 µM TDZ regeneration medium for 5, 10 or 20 days in the dark. Both microprojectile-treated and control explants exhibited 85-100% regeneration. However, only 30-60% of the explants bombarded at 7.6, 9.3 and 13.8 MPa had more than 10 regenerants and 6-10% had more than 20 regenerants, whereas for control explants and those bombarded at 4.5 and 6.2 MPa, 70-90% had more than 10 regenerants and 30-50% had more than 20.

649 (PS 4)

ISOLATION AND CULTURE OF DAYLILY MESOPHYLL PROTOPLASTS

Jing-Tian Ling* and Roger J. Sauve Department of Agricultural Sciences, Tennessee State University, Nashville, TN 37209-1561

Mesophyll protoplasts were isolated from a diploid daylily (Hemerocallis cv.'Red Magic') by enzyme digestion with a solution containing 0.5% Pectolyase Y-23, Cellulase R-10 1.0%, Driselase 0.1%, Sorbitol 0.6M and half-strength MS inorganic salts at 60 rpm for 4 h. The protoplasts underwent sustained division to produce multicellular colonies on a MS medium supplemented with 0.5 mg/l NAA and 0.5 mg/l BA. The optimal plating density for cell division was 5 X $10^4$ cells per ml. Cultures grown in agarose-bead media resulted in higher plating efficiencies that of those in solidified or liquid media. Under the above conditions, formation of colonies occurred in 8 to 11% of the cultured protoplasts. Research is in progress for the production of callus from protoplast-derived colonies and for the generation of plantlets from callus.

650 (PS 4)

FIELD PERFORMANCE OF MUSCADINE GRAPE MICROPROPAGATED FROM SHOOT TIPS

Carol D. Robacker* and R.P. Lane, Dept. of Horticulture, Georgia Station, Experiment, GA 30223

Phenotypic stability and yield of muscadine grape (Vitis rotundifolia) plants produced via micropropagation from shoot tips must be demonstrated to overcome reluctance to use micropropagated plants in vineyards. 'Golden Isles' plants produced from culture of fragmented shoot tips were planted in the vineyard, and yield data were collected three, four and five years after planting. Yield of four-year old vines was comparable to that collected in earlier years at this location from 'Golden Isle' plants from stem cuttings. Yield in the fifth year, however, declined significantly, perhaps due to late cold spring weather or heavy fruiting the previous year on these young vines. After five years in the vineyard, trunk diameter, shoot length, leaf area, berry size and soluble solids of the micropropagated plants were compared to those from stem cuttings. The only difference detected was for soluble solids, a trait highly influenced by environmental conditions. All micropropagated plants appeared similar to each other and to the 'Golden Isles' cultivar.

651 (PS 4)

REGENERATION OF HYPOCOTYL EXPLANTS OF GARDENEGGS (*SOLANUM GILO*)

Essie T. Blay*, Anant Porobo-Dessai (Calgene Fresh, Inc., Davis, CA 95616), and C.S. Prakash (School of Agriculture, Tuskegee University, Tuskegee, AL 36088

The success of crop transformation is contingent upon the efficient regeneration of cocultivated explants. This study was initiated as part of a transformation program designed to solve some critical problems in gardenegg, an important solanaceous fruiting vegetable in many tropical African countries. A preliminary investigation involving the screening of cotyledons, hypocotyl, and leaf explants on zeatin-, kinetin-, or BAP-supplemented media produced regeneration in all explant types, but hypocotyl explants were consistently faster and produced more plantlets/explants. In this study, hypocotyl explants excised from 2-week-old seedlings cultured on media composed of MS salts supplemented with 2% sucrose, 0.9 mg/l thiamine-HCl, 2 mg/l glycine, 1–4 mg/l zeatin, zeatin riboside, or BAP, and 3.5% phtyagel. Zeatin and zeatin riboside induced the fastest and most prolific shoot intiation. Rhizogenesis, however, was better on BAP-supplemented media. All plantlets rooted readily when transferred onto a hormone-free medium. As many as 28 plantlets/explants were obtained in some treatments. Rooted explants transferred into potted soil mix and acclimatized for 2 weeks in a growth chamber grew normally.

652 (PS 4)

LIQUID MEDIUM OVERLAYS ENHANCE GROWTH AND MULTIPLICATION OF IN VITRO APPLES AND GRAPES

Masooma Ali Ahmad*, Farida Safadi, and Harrison Hughes, Department of Horticulture. Colorado State University, Fort Collins, CO 80523

Previous studies have shown that liquid medium additions on established cultures enhance shoot growth and proliferation. In the present report, the growth and multiplication of apples and grapes were evaluated after the addition of liquid media to established cultures. Grapes and apples were micropropagated on agar solidified nutrient medium with 5$\mu$M BAP, and 4.4$\mu$M BAP, 1.4$\mu$M GA, 4.9$\mu$M IBA, respectively. A liquid overlay of similar medium was added after 4 to 6 weeks in both cultures. Improved growth, number of shoots, and a reduction in callus growth were observed in both species as compared to shoots transferred to fresh solid media. The number of micropropagated apple shoots and their height increased significantly by 35% and 69% respectively. Proliferation of grape shoots increased by 198% while callus growth decreased by 64% when compared to cultures transferred to fresh solid media.



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# POSTER SESSIONS 1–16 (Abstr. 550–955)

550 (PS 1)

IMPROVED EMERGENCE OF *SOLANUM TORVUM* BY SEED TREATMENT

H. Miura*, M. Yoshida and A. Yamasaki, Kurume Branch, National Research Institute of Vegetables, Ornamental Plants and Tea, 1823, Mii-machi, Kurume, 830 Japan.

Several soilborne diseases severely affect eggplants (*Solanum melongena* L.) in Japan. Therefore, eggplants are usually grafted on rootstocks of various species resistant to these diseases. For the control of verticillium wilt (*Verticillium dahliae* Klebahn), *Solanum torvum* 'Torvum vigor' plants are used for rootstocks. However since the seeds started to emerge after 12 - 14 days at 25C and only 40% of them emerged after 30 days, it was difficult to obtain seedlings of uniform size.

In this experiment, matric priming treatment of seeds prior to planting was modified to improve the emergence of the seeds of 'Torvum vigor'. Vermiculite powder was selected as the substrate to control the water potential of seeds during the treatment. First, samples of 0.25g seeds (235seeds on an average) were mixed with various amounts of vermiculite powder and water at 25C in the dark during 1 week. Thereafter, the treated seeds were planted in soil and incubated at 25C under a 12h daylength regime and the emergence and growth were monitored. Second, the temperature for the treatment, growth regulators added to water, air pressure and components, and the duration of the treatment were varied. Finally, the optimum treatment for improving the emergence of *Solanum torvum* seeds was developed.

551 (PS 1)

EFFECTS OF TESTA REMOVAL ON BROCCOLI SEED GERMINATION

Lewis W. Jett and Gregory E. Welbaum, Department of Horticulture, Virginia Polytechnic Institute & State University, Blacksburg, VA 24061.

The testae of seeds from the genus *Brassica* are not considered to constitute a significant barrier to radicle growth. It is hypothesized that in these seeds the testa splits during imbibition prior to the onset of radicle emergence. To test this hypothesis, the structural anatomy, the rate of hydration, the base water potential ($\Psi_b$), and the rate of germination of broccoli (*Brassica oleracea* L.) seeds were examined for both intact and decoated, primed and nonprimed seeds. Both primed and nonprimed seeds exhibited a marked increase in the rate of imbibition. The germination rates of primed and nonprimed decoated seeds were greater at all $\Psi$'s compared to intact seeds. Priming did not lower the $\Psi_b$ of intact seeds. Removing the testa reduced the $\Psi_b$ of both primed and nonprimed seeds. Observation of germinating seeds indicated that the testa was ruptured during the initial stages of radicle growth and not during the plateau phase of imbibition as previously believed. Priming did not appear to cause premature cracking or weakening of the testa. Priming did cause an irreversible change in volume due to free space that developed between the testa, radicle, and cotyledons. Thus, the testa of broccoli seeds does provide a barrier to radicle emergence that must be overcome by the expanding radicle during germination.

552 (PS 1)

EFFECT OF GRAIN SORGHUM ON GERMINATION OF WEED AND CROP SEEDS

M. L. Hoffman* and L. A. Weston, Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington, KY 40546.

Sorghum species are frequently used by horticultural producers as cover crops or green manures. Grain sorghum cover crops are often used in the southern United States. These summer annual grasses grow rapidly producing large quantities of biomass that has been shown to suppress weeds. Although allelochemicals in the roots and shoots have been identified, the precise mode of weed suppression has not been clearly elucidated. We performed a series of studies to evaluate the effect of sorghum on the germination of various weed and crop seeds. Petri dish assays were used to test the effect of germinating sorghum seed on the indicator species. Treatments were arranged in a completely randomized design with 4 replications and 2 experimental runs. Data collected included % germination as well as radicle and hypocotyl length. A modified Parker bioassay using 4 and 8 week old sorghum root and shoot tissue was used to study the effects of sorghum tissue on seed germination of the indicator species. Sorghum residue was observed to inhibit weed and crop seedling growth resulting in chlorosis of susceptible species.

553 (PS 1)

SEED TREATMENT EFFECTS ON VOLATILE ALDEHYDE PRODUCTION IN GERMINATING *sh2* SWEET CORN.

Thomas E. Paine* and Mark A. Bennett, Department of Horticulture, The Ohio State University, 2001 Fyffe Ct, Columbus, OH 43210-1096.

Seeds of two shrunken-2 (*sh2*) sweet corn (*Zea mays* L.) cultivars, 'Crisp'n Sweet 710' and 'Camelot', were used to relate volatile production to seed quality and seedling establishment. The five seed treatments evaluated were a hydration and drying cycle, a biological control of *Pythium*, a hydration and drying cycle followed by a biological control, a fungicide treatment, and an untreated check. For the aldehyde assays, 50 seeds were germinated in a flask for 24 h with a test tube of a 3-methyl-2-benzo-thiazolinone hydrazone (MBTH) solution. One ml of the solution was then reacted with $FeCl_3$, diluted with acetone, and absorbance read at 635 nm. A field study was run under cool soil conditions (10-16°C) for seedling emergence and growth. Aldehyde production from the seeds did not correlate with field results for seed treatments, but did show a distinct difference between cultivars. The biological control with the hydration and drying cycle significantly reduced aldehyde production. This may contribute to the effectiveness of biological treatments since *Pythium* spores can be stimulated by volatile compounds released from germinating seeds.

554 (PS 1)

PRIMING TEMPERATURE AND SALT CONCENTRATION EFFECTS GERMINATION OF PEPPER SEED AT LOW TEMPERATURES

Anne K. Carter*, NMSU Agricultural Science Center, Star Route Box 77, Clovis, NM 88101

*Capscicum annuum* L. var Vera Cruz seeds were primed at 15°C or 23°C for 5 days in 0, 200, 400, 600mM NaCl. The seeds dried for 3 days. Treatments plus an unprimed control were germinated in an incubator at 15° or 23°C . Germination was recorded daily and maximum % germination, (MaxG), mean daily germination (MDG) and $T_{50}$ were calculated. Treatments were as follows: 23°C prime, 23°C germination (23P23G), 23P15G, and 15P15G. The 0mM NaCl priming treatment had over 50% germination during the priming process, thus germination was not recorded. *P23G23* - MaxG was the same for all treatments . The $T_{50}$ and MDG were improved by approximately 2 days for the 200mM and 400mM treatments. *P15G15* - None of the seeds germinated in any of the treatments after 10 days. *P23G15* - The 200, 400, and 600mM priming treatments improved MaxG, MDG, and $T_{50}$ over the unprimed control, but were not different from each other. However, the MaxG was between 50-60% as compared to 90-95% in the P23G23 treatment. While priming at 23°C does allow seeds to germinate at cold temperatures, other treatments are necessary to improve MaxG.

555 (PS 1)

SOIL TEMPERATURE AND EMERGENCE OF WARM-SEASON VEGETABLES

Joanne Logan*, Marcella A. Mueller and Thomas B. Coffey, Department of Plant and Soil Science, P. O. Box 1071, The University of Tennessee, Knoxville, TN 37901-1071

In Tennessee, the 10% freeze probability dates occur during early April in most of the state. However, due to cool soils, most warm season vegetables are not planted until after May 1. The objective of this study was to quantify and map the soil temperature (2.5-5 cm depth) requirements for emergence of okra, sweet corn, cucumber, summer squash, snap bean and southern pea using different methods of temperature calculations. Field studies were conducted in Knoxville and Crossville, Tennessee in 1991 and 1992. Results show that the range of minimal average soil temperature for acceptable seedling emergence is 14 to 18°C, which is reached by mid-April in most of the state. Average soil temperature appears to be a better indicator of time to 50% emergence than other temperature-based calculations. It can be estimated from daily readings of present soil temperature in the early morning and mid-afternoon, or from air temperature, if necessary. Soil temperature maps, created in a geographic information system, can be very useful in selecting appropriate planting times for warm season vegetables.



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660 (PS 4)

INFLUENCE OF AGAR AND AMMONIUM NITRATE ON TISSUE NITROGEN, CULTURE GROWTH, AND VITRIFICATION

Mark H. Brand*, Department of Plant Science, University of Connecticut, Storrs, CT 06269-4067

Shoot tips of *Amelanchier* were grown on Murashige & Skoog (MS) or Woody Plant (WP) medium containing 4.4 μM benzyladenine and 4, 6 or 8% Difco Bactoagar. Increasing agar concentration reduced culture fresh weight, dry weight, and vitrification, but increased tissue nitrate concentrations. The number of shoots produced per culture was unaffected by agar concentration. Overall, response to agar additions was similar for shoots on both WP and MS salts, although the magnitude of the response may have differed. *Amelanchier* shoots cultured on WP medium containing 4% agar and 10.5, 15.5, 20.9 or 25.5 mM nitrate showed a linear increase in culture fresh weight, culture dry weight, number of shoots per culture and number of vitrified shoots per culture as medium nitrate concentration increased. Nitrate and total nitrogen content of explants also increased linearly with increasing medium nitrate concentration. Although vitrification has been previously ascribed to elevated ammonium concentrations in culture media, it is possible that elevated medium and tissue nitrate levels may also play a role in vitrification.

661 (PS 4)

PLANT REGENERATION AND TRANSFORMATION IN *COREOPSIS LANCEOLATA*

Joel T. Nichols*, Lijuan Wang, and Chiwon W. Lee, Department of Horticulture and Forestry, North Dakota State University, Fargo, ND 58105

Leaf discs of *Coreopsis lanceolata*, when cultured on Murashige and Skoog (MS) medium supplemented with 10 μM benzyladenine (BA) and 1 μM naphthaleneacetic acid (NAA), produced shoots in four weeks. Shoots were often induced on the marginal tissues of the leaf discs without callus formation. The frequency and the number of shoots induced per leaf disc varied slightly when growth regulator combinations of 0.5-40 μM BA and 0-2 μM NAA were tested. Most shoots produced roots on the same regeneration medium after formation of 3 to 5 leaves. The rooted plants were established in soil within 3 months from initial culture. For genetic transformation, leaf discs were infected with *Agrobacterium tumefaciens* Strain LBA 4404 carrying both kanamycin resistance and β-glucuronidase (*GUS*) genes. Shoots were induced from these leaf discs on the regeneration medium containing 250 mg/liter kanamycin. The histochemical assay showed that the regenerated shoots were *GUS* positive.

662 (PS 4)

MICROPROPAGATION OF GAS PLANT (DICTAMNUS ALBUS)

Rodney Jones* and Robert Geneve, Department of Horticulture and L.A., Univ. of Kentucky, Lexington, Kentucky 40546-0091.

Gas plant is an elegant ornamental which blooms in early summer. It is commonly propagated by seed which is limited by a complex dormancy. Micropropagation was investigated as an alternative method for efficiently propagating gas plant. Rapidly growing two node stem pieces were taken from mature greenhouse grown plants, surface sterilized and placed in MS medium with 1 μM benzyladenine (BA). Shoot multiplication was studied using in vitro derived four node explants cultured on MS media containing BA at 0, 1, 5, or 10 μM. Explants cultured on BA at 1 and 5 μM averaged 3.9 and 5.6 shoots per explant respectively and a mean yield of 2.7 and 2.5 shoots greater than 2 cm in length. Explants cultured at 10 μM produced 5.7 shoots per explant with only 0.8 shoots greater than 2 cm in length. Microcuttings failed to root in vitro even in the presence of indolebutyric acid (IBA). Microcuttings directly stuck ex-vitro in a peat-lite medium root at 90% with 1.9 roots per cutting.

663 (PS 4)

THE DEVELOPMENT OF TRICHOME-LIKE STRUCTURES IN CALLUS CULTURES OF SPRING BEAUTY (CLAYTONIA VIRGINICA)

Sharon T. Kester*, Robert L. Geneve and Rodney O. Jones, Dept. of Horticulture, Univ. of Kentucky, Lexington, KY 40546

Tissue cultures were initiated in spring beauty from petal or sepal tissue on a MS medium. Using a factorial combination of naphthaleneacetic acid and kinetin, only sepal tissue responded to form callus. Callus proliferating on the 5.4 μM NAA + 9.3 μM KN would periodically form shoots at a low frequency. After six months in culture on this medium, trichome-like structures developed along the surface of the proliferating callus. Two types of trichome-like structures were observed in these cultures. One type was a multibranched structure and the second type was linear with a glandular tip. The trichome-like structures were assimilated as the callus mass increased in size. In addition, the cells in the callus just below the surface were pigmented. The pink pigment was visually similar to the natural petal coloration. Leaf, sepal and petal tissue did not produce obvious trichomes on greenhouse grown plants.

664 (PS 4)

ADVENTITIOUS SHOOT FORMATION IN EASTERN REDBUD (CERCIS CANADENSIS)

Karsedis Distabanjong* and Robert L. Geneve, Dept. of Horticulture and L.A., Univ. of Kentucky, Lexington, KY 40546

Adventitious shoot induction was studied using isolated parts of in vitro grown seedlings of Eastern redbud. The explants studied included the cotyledon node (with or without cotyledons), cotyledon, hypocotyl, epicotyl, root, nodal stem and seedling leaf pieces. Explants were treated with a factorial combination of benzylaminopurine (BAP) and thidiazuron (TDZ) on DKW medium. Cultures of Eastern redbud produced a low frequency of adventitious shoot formation for all explants tested except for explants with the cotyledonary node. These explants produced 5.9 shoots per culture after treatment with 10μM BAP + 1μM TDZ. However, shoots produced on a medium containing TDZ failed to elongate. Many of the TDZ induced shoots were abnormal and distorted. Shoot elongation was promoted by transferring explants to a medium with BAP alone.

665 (PS 4)

THE PRODUCTION OF HAPLOID CALLUS FROM ANTHER CULTURE IN SWEET CHERRY (*PRUNUS AVIUM* L.)

Christopher M. Long, Amy F. Iezzoni and Colleen A. Mulinix, Michigan State University, East Lansing, MI 48824

Map development in Angiosperm tree crops is hampered by the lack of suitable mapping populations and the time and space required to grow large progeny populations. An alternate strategy for developing a linkage map for sweet cherry using haploids derived from anther culture as the progeny populations is being developed. The genetic markers will be RAPDs which segregate 1:1 among the progeny. Our initial objective is to obtain haploid microspore-derived callus cultures from sweet cherry. Two sweet cherry cultivars, Bing and Emperor Francis, were chosen which are heterozygous for *Pgi*, and *Pgi* and 6-*Pgd*-1, respectively. Branches were forced in the laboratory. When the microspores reached the uninucleate stage the anthers were plated on medium containing 4.4 uM BA and 4.5 uM 2,4-D. After ≈50 days, callus which burst from the anther was placed on Woody Plant Medium supplemented with 1 uM 2,4-D and 3 uM 2iP and routinely transferred. To date, 64 callus cultures from Emperor Francis exhibited only one allele each from *Pgi* and 6-*Pgd*-1 and are therefore putative haploids. Four callus cultures of Bing exhibited only one allele for *Pgi*.

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GROWTH RESPONSES OF YOUNG APPLE TREES ON 3 ROOTSTOCKS TO DROUGHT STRESS

R.T. Fernandez*, R.L. Perry and J.A. Flore, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325.

'Imperial Gala' apple trees on M.9 EMLA, MM.111 and Mark rootstocks were subjected to two drought and recovery periods in a rainshelter. The objectives were to determine rootstocks adaptation and parameter sensitivity to drought stress. Leaf growth rate, area, emergence; shoot length, trunk cross sectional area and gas exchange were measured for each stress and recovery period. Leaf growth rate was most consistently reduced by drought and returned to control levels when irrigated. Length of less vigorous shoots was consistently reduced by stress but did not recover upon irrigation. Leaf emergence and trunk cross sectional area were inconsistent in response to stress. Growth of trees on Mark rootstock was reduced to the greatest extent by drought followed by MM.111 and M.9 EMLA. At termination plants were separated into roots, 1-year and 2-year shoot growth and rootstock to determine dry weights. Dry weights confirmed the growth measurements with a 34%, 27% and 16% reduction in total plant dry weight for drought stressed trees on Mark, MM.111 and M.9 EMLA, respectively. The greatest differences in estimated whole plant photosynthesis were for trees on Mark rootstock followed by MM.111 with the least differences for M.9 EMLA which reinforced the growth measurements. It was concluded that Mark was most sensitive followed by MM.111 with M.9 EMLA being most tolerant to drought.

525

RESPONSES OF YOUNG PEACH TREES TO ROOT CONFINEMENT

Mark Rieger* and Franco Marra, Department of Horticulture, University of Georgia, Athens, GA 30602.

Rooted cuttings of Nemaguard peach (*Prunus persica* (L.) Batsch.) were grown in 0.18, 0.36, 0.90, and 2.40 liter containers for 16 weeks to study the influence of root confinement on growth, gas exchange, water uptake, and leaf carbohydrate and nutrient content. Leaf area and stem length were reduced by root confinement beginning 6-7 weeks after transplanting, and differences among treatments increased through week 16. Final tree dry weights were reduced 51% over a 13-fold change in rooting volume, but dry weight partitioning was largely unaffected. Consistent reductions in $CO_2$ assimilation and leaf conductance for confined trees did not occur until after week 11. Sorbitol and starch accumulated earlier in leaves of trees in smaller containers, but sorbitol was reduced and starch was unaffected by container volume at week 16. Despite similar soil fertility, leaf nutrient concentrations were reduced ≈two-fold by root confinement, except N (reduced 38%), yet characteristic deficiency symptoms were not observed. Initial mechanism(s) limiting growth were not gas exchange rates, levels of nonstructural carbohydrates, or drought stress, although nutrient deficiency cannot be ruled out as a factor limiting growth of trees with restricted rooting volume.

526

CONVERSION OF BOUND TO FREE WATER IN ENDODORMANT APPLE BUDS

M.FAUST, D.LIU, M.J.LINE AND G.W.STUTTE . Fruit laboratory, and Environmental Chemistry Laboratory, Beltsville Agricultural Research Center, Beltsville, MD 20705 and Bionetics Corp. Kennedy Space Center,FL 32899.

Proton Density and T2 maps were created throughout the dormant season in 'Anna' and Northern Spy' apple cultivars. The percentige of oixels with 15-25 ms T2 time increased from 30% in both cultivars at the beginning of dormancy to 80 and 72% respectively, by the end of dormancy. The conversion in 'Anna' was rapid and in 'Northern spy was slow. Growth occured only when conversion of bound to free water reached 70% of the total number of pixels. Buds entered into a transitional phase when conversion of water reached 50%. Buds in the transitional phase are willing to respond to treatments aimed to end dormancy. Thus dormancy can be divided into two major part based on the boundness of freeness of water in the bud.

527

DROUGHT, LEAF GAS-EXCHANGE, AND WATER RELATIONS OF PAPAYA

Thomas E. Marler* and Michael V. Mickelbart, College of Agriculture & Life Sciences, Univ. of Guam, UOG Station, Mangilao, Guam 96923

A series of container studies was conducted from Sept. 1991 through July 1992 in which papaya plants were subjected to drying and re-wetting cycles to determine short term leaf gas-exchange and water relations responses to drought. The first response of papaya plants to a decline in substrate matric potential was a rapid reduction in stomatal conductance and net photosynthesis. Apparent quantum yield was reduced and light compensation point was increased shortly thereafter as stress continued to develop. However, leaf gas-exchange rapidly returned to the level of control plants after re-wetting. There was minimal or no effect of drought stress on relative leaf water content, pre-dawn xylem potential, dark respiration, the ratio of variable to maximum chlorophyll fluorescence, osmotic potential of leaf or root tissue, or root hydraulic conductivity of papaya plants. Chlorosis and shedding of the oldest leaves occurred following rewatering. These results indicate that papaya plants respond to short term drought by dehydration postponement via maintenance of water uptake and reduction of water loss.

## 215 ORAL SESSION 61 (Abstr. 528–535) Woody Ornamentals: Growth and Development II

528

NITROGEN AND CARBON TRANSLOCATION DURING EPISODIC GROWTH OF *LIGUSTRUM JAPONICUM* AND EFFECTS OF NITROGEN AND/OR LIGHT DURING DIFFERENT GROWTH EPISODES

Jeff S. Kuehny*, Dennis R. Decoteau, and Mary C. Halbrooks, Department of Horticulture, Clemson University, Poole Ag Building, Box 340375, Clemson, SC 29634-0375.

Pulse-labels of $^{15}N$ and $^{14}C$ were used to determine nitrogen and carbon translocation during episodic root and shoot growth. Stored nitrogen ($^{15}N$) was translocated to both the first and second episode of shoot growth. Autoradiographs of $^{14}C$ labeled plants indicated that fixed carbon was predominately translocated to roots during an episode of root growth and to shoots during an episode of shoot growth. Exclusion of nitrogen and/or light during different growth episodes decreased shoot length, leaf area, and fresh weight, thus affecting the root:shoot ratio for each episode. Translocation of newly fixed carbon and stored nitrogen between the shoots and roots of Ligustrum, and the supply of nitrogen and/or light are important factors that help maintain the functional balance of each episode of growth.

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EFFICACY OF A COPPER HYDROXIDE/LATEX PAINT FORMULATION FOR ROOT - PRUNING 41 SPECIES OF CONTAINERIZED NURSERY STOCK

Randon L. Krieg* and W. T. Witte, Department of Ornamental Horticulture & Landscape Design, University of Tennessee, Knoxville, TN 37901-1071.

The root system of containerized nursery stock may become undesirably coiled or matted on the outer surface of the media. Various copper formulations painted on the interior of the container surface have been shown to control undesirable root growth in a few species. We tested a commercial formulation of 100 g/l copper hydroxide in a flowable latex paint formulation (SpinOut™) on 41 tree, shrub, and herbaceous species. Plants were grown 4 months in 7.5x7.5x15cm containers, either treated or untreated. Root density was evaluated on a scale of 1 to 5 (no roots on the surface to heavy rooting). Analysis showed treated containers prevented roots from growing on the media surface in all species tested except *Magnolia liliiflora* 'Jane', *Buxus sempervirens* 'Vardar Valley', and *Taxus x media* 'Hicksii', where control of surface rooting was significant but moderate. Copper paint did not inhibit growth of stolons or rhizomes, which morphologically are stem structures. No visual signs of copper toxicity were observed, nor were there any differences in shoot growth.



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formulations of paclobutrazol reduced plant size. Plants grown in the peat-based media were more sensitive to paclobutrazol than those grown in bark-based media. Stem length of those plants treated with paclobutrazol spikes was less than those treated with an equal amount of paclobutrazol as a drench in all media except the Rockwool Mix and Metro 702.

673 (PS 5)

PINE BARK-AND PEAT-BASED MEDIA INFLUENCE THE EFFECTS OF PACLOBUTRAZOL AND UNICONAZOLE DRENCH ON 'GUTBIER V-14 GLORY' POINSETTIAS.

Steven E. Newman*, Jeffrey S. Tant, and Jesse R. Quarrels, Department of Horticulture, Mississippi Agricultural and Forestry Experiment Station, P.O. Drawer T, Mississippi State, MS 39762-5519.

The objective of this study was to determine the influences of 8 commercial media, 4 peat-based and 4 pine bark-based, on the effects of paclobutrazol and uniconazole applied as a media drench to 'Gutbier V-14 Glory' poinsettias. The peat-based media were Baccto Grower's Mix, Baccto High Porosity Professional, Baccto High Porosity Professional with Bacctite, and Baccto Rockwool Mix. The pine bark-based media were Metro 360, 366, 700, and 702. Paclobutrazol and uniconazole were each applied to plants grown in each media at 5 rates (0, 0.125, 0.250, 0.375, and 0.500 mg·15 cm pot$^{-1}$). Paclobutrazol and uniconazole effectively reduced plant height in all media. Plants grown in the Metro products, however, tended to be larger than those grown in the Baccto products. Plants grown in the peat-based media were more sensitive to growth regulator drenches. Plants grown in Metro 360 and 366 were the least sensitive to plant growth regulator drenches compared to the Baccto media.

674 (PS 5)

EFFECTS OF SURESTEM PLANT GROWTH MODIFIER ON STEM NUMBER, LENGTH, AND QUALITY OF HYBRID TEA ROSES GROWN IN GREENHOUSES

Cyril A. Kust, ARS-USPD, American Cyanamid Company, P.O. Box 400, Princeton, NJ 08543-0400

SURESTEM plant growth modifier, applied in foliar sprays at 80.0 g ai/H to regrowing stems following rose stem harvest, increased Royalty variety hybrid tea rose stem number and length and improved stem quality. Stem numbers per harvest were increased in Samantha and Kardinal variety roses, but there were no changes in stem quality or stem length. For rose stems harvested on a growth cycle basis, excellent stem number increases were obtained when SURESTEM was applied about 7 days after 90% of the stems had been harvested. The best time of application was affected by temperature and light conditions in the greenhouse, by natural photoperiod in the absence of artificial lighting, and by stem harvest practices of the growers. The best time of application for plants managed on a continuous stem harvest system has not yet been determined. Commercial producers of long-stem roses are evaluating SURESTEM under an EPA Experimental Use Permit issued April 7, 1992. The EUP program and label also permits the evaluation of SURESTEM on other ornamental crops grown for cut stem production in greenhouses.

675 (PS 5)

**GROWTH RETARDATION OF NARCISUS TAZETTA DURING FORCING**

R. A. Criley and C. L. Chia, Dept. Horticulture, University of Hawaii, Honolulu, HI 96822

Bulbs of the Chinese Sacred Lily (Narcissus tazetta) are forced in water about 28 days before Chinese New Year. Excessive leaf and scape length may necessitate tying to render the plants presentable. No. 1 bulbs which had been cleaned and placed in water for 2 days were treated with 10 ppm ancymidol, 50 ppm paclobutrazol, 25 ppm uniconzole, 10 ppm flurprimidol, or 100 ppm ethephon. At 70% of control plant height, ethephon-treated plants were shortest, and flowering was not delayed. Daughter bulbs were soaked in 50 ppm flurprimidol to determine the most effective stage at which to treat. Soaking the dry bulbs for 1 hour at 36°C was most effective (58% of control), but delayed flowering more than a week. Soaking the bulbs for one hour when emerging roots were @ 0.5 cm long was also effective (65% of control). At 11 days of forcing when emerging leaves were 4 - 6 cm long, the entangled root sytems were soaked in the retardant which was then drained off. This treatment achieved 74% of control growth. Scape lengths in all flurprimidol treatments were 60-65% of the foliage length compared to 82% for the controls.

676 (PS 5)

EFFECT OF UNICONAZOLE RATE AND TIME OF APPLICATION ON MORPHOLOGICAL QUALITY CHARACTERISTICS OF MINIATURE POT ROSES

T. M. Kyalo[1], H. B. Pemberton[1]*, J. M. Zajicek[2], and G. V. McDonald, [1]Texas Agricultural Experiment Station, P.O. Box E, Overton, TX 75684 and [2]Texas A&M University, Dept. of Hort., College Station, TX 77843

Uniconazole was sprayed at 25, 50, 75 or 100 mg·liter$^{-1}$ on plants of Rosa L. 'Meirutral', 'Meijikatar' and 'Meilarco' in experiments at Overton and College Station. A short cycle production schedule was used consisting of liner establishment in 11.4 cm pots, severe cut back and a final forcing period. In late summer experiments, the 25 mg·liter$^{-1}$ treatment reduced plant height, peduncle length and increased days to harvest by 3 days, but either increased or had little effect on the number of flowers. All cultivars were affected similarly. Higher concentrations severely reduced plant height, number of flowers, peduncle length and caused a slightly longer delay in days to harvest. Application of uniconazole to new shoots that had grown 5-7 cm long after the cut back was as effective in reducing plant height as a split application (half the full rate at each time) made when new shoots were 5-7 cm and when new shoots exhibited pea size buds. A single application at pea-bud stage was not effective in controlling height. When experiments were repeated in early spring, uniconazole had a stronger effect on plants than in the summer. Further research is needed concerning the interaction of environmental variables and uniconazole rate for optimum control of pot rose growth.

677 (PS 5)

EFFECT OF GROWTH REGULATORS ON HEIGHT OF PENTAS

G. J. Wilfret* and B. K. Harbaugh, GCREC, IFAS, Univ. of Fla., 5007 60th St. E., Bradenton, FL 34203

Pentas (P. lanceolata Benth.) cv. Ruby Glow Red single node cuttings were grown in 15 cm pots in a glasshouse and developing laterals were pinched to one node. Plants were sprayed with chlormequat (CCC) at 0, 500, 1000, 1500, or 2000 ppm on 5, 10, or 15 days after pinching. An ancymidol (0.5 mg ai/15 cm pot) drench treatment was applied at the above 3 dates. Application date had no effect on plant height and ancymidol had minimal effect. All CCC treated plants were shorter than controls but little differences were recorded among CCC conc. Since most stem elongation occurred after the inflorescence was ca. 2 cm diam., a second experiment with similarly grown plants consisted of CCC sprays of 0, 500, 1000, 2000, or 4000 ppm applied 10 days after pinching. Additional CCC applications were made when the inflorescence was 2 cm diam. All treatments yielded plants shorter than controls which were 57 cm. Plants sprayed initially with CCC at 2000 ppm plus CCC at either 500, 1000, or 2000 ppm at the bud stage ranged from 28 to 32 cm tall, an ideal height range for 15 cm pots. CCC at 4000 ppm appeared to reduce stem turgidity and the inflorescence tended to droop at maturity.

678 (PS 5)

**HYBRID LILY RESPONSES TO DAY/NIGHT TEMPERATURE REGIMES (DIF), GROWTH RETARDANTS, AND GROWING MEDIA COMPOSITION.**

**George J. Wulster and Don Tonkin, Plant Science Dept. Rutgers University, New Brunswick NJ 08903-0231.**

**Hybrid lilies(4 oriental & 2 asiatic) species were grown in commercial potting media formulations containing various percentages of composted bark. Lilies were grown in greenhouse sections maintained at either 21C day temperature and 15C night temperature or 15C day temperature and 21 C night temperature from emergence until anthesis. The growth retardants Paclobutrazol (Bonzi) and Uniconazole (Sumagic) were applied as a media drench at 0.25 mg a.i. per pot. Final height, days to flower from planting, days to flower from visible bud, and flower number were recorded for each treatment. Plant height was significantly reduced by potting media formulation, growth retardant treatment, and temperature regime. The effects of these treatments on bud number, and days to flower will also be discussed.**



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512
GROWER SELF-EVALUATION AS AN EXTENSION TOOL
John F. Kelly*, Bernard H. Zandstra and Norman L. Myers, Department of Horticulture, East Lansing, MI 48824-1325

A self-administered response to production-related questions, based on the most recent recommendations for the production of asparagus, was used to identify strengths and weaknesses of growers on an individual or group basis. Points were assigned to the various responses, and growers were evaluated relative to the group of respondents. Individual grower evaluation summaries were returned to the county horticultural agent for use in individual grower consultations. This report discusses the specific issues related to asparagus production and presents factors to be considered in preparing and evaluating such a tool.

## 213 ORAL SESSION 59 (Abstr. 513–519) Cross-commodity: Propagation

513
PRE-GERMINATION TREATMENTS INFLUENCE GERMINATION AND PLANT SURVIVAL OF YUCCA GLAUCA GERMINATED ON LS MEDIUM
Jody J. Brott* and Paul E. Read, Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724

Seeds from three phenotypes of Yucca glauca were germinated using two pre-germination treatments for each phenotype. Treatments were: a 10% NaOCl (10 NaOCl) soak for 15 minutes and a 50% NaOCl (50 NaOCl) soak for 24 hours. Seeds were then placed on Linsmaier-Skoog (LS) medium in darkness for two weeks at 27-28 C. All radicles were emerging through the seed coats at the end of 50 NaOCl as compared to no visual difference in the seed appearance after 10 NaOCl. At the end of the two incubation periods, seeds from 50 NaOCl exhibited shoot development and elongation while seeds from 10 NaOCl exhibited little or no shoot development or elongation. Seeds from 10 NaOCl exhibited contamination and/or "bleeding" (phenolic exudates) within 4 weeks. All seedlings were transferred to fresh LS medium and cultured for 6, 12 and 18 weeks. Seedlings that received the 50 NaOCl developed fibrous roots at 8-10 weeks and the beginnings of a tap root at 16-20 weeks. Ten seedlings from 50 NaOCl were transplanted 9 months after germination.

514
TRANSPLANT TECHNIQUES & TIMING INFLUENCE SURVIVAL OF YUCCA GLAUCA TRANSPLANTS.
Jody J. Brott* and Paul E. Read, Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724

Juvenile Yucca glauca plants, with a fibrous, woody rhizomatous root still connected to the mother plant and well developed basal fibrous roots that were present when they were transplanted prior to tap root development, exhibited faster recovery from transplant stress and earlier bloom as compared with juvenile plants transplanted with fully developed immature taproots. All juvenile transplants exhibited >90% survival as compared with mature transplants with fully developed taproots, none of which survived. Juvenile transplants with no taproot development prior to transplanting recovered and produced flower stalks with full bloom within 2 years of transplanting. Juvenile transplants with taproot development took 3 years from transplant to recover and produced flower stalks with full bloom.

515
Effects of IBA and Branch Position on Rooting Softwood Cuttings of 'Yoshino' Cryptomeria
Laura G. Jull*, Stuart L. Warren and Frank A. Blazich, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Softwood stem cuttings of Cryptomeria japonica (L.f.) D. Don 'Yoshino' consisting of (1) tips (terminal 20 cm) of first order-laterals (secondary axes), (2) the distal half (terminal 10 cm) of tips of first-order laterals, (3) the proximal half (basal 10 cm) of tips of first-order laterals or (4) tips (terminal 10 cm) of second-order laterals (tertiary axes) were treated with 0, 3000, 6000 or 9000 ppm 1H-indole-3-butyric acid (IBA) and placed under intermittent mist for 12 weeks. IBA treatments did not effect percent rooting, root number, root length, or root dry weight. Tips of first-order laterals and the proximal half of first-order laterals yielded the highest rooting percentages (75% and 78%, respectively), whereas the distal half of the first-order laterals and tips of second order laterals rooted in lower percentages (50% and 34%, respectively). Tips of first-order laterals and the proximal half of first-order laterals both produced 4.5 roots per cutting. Root length, root area and root dry weight were also highest with these two branch positions.

516
DOSE RESPONSE CURVES AND CARRIER EFFECTS ON ROOTING
Brian K. Maynard* and William A. Johnson, Department of Plant Sciences, University of Rhode Island, Kingston, RI 02881.

Auxins are indispensable for vegetatively propagating many woody plants. The rooting of stem cuttings treated with auxin varies with shoot maturation, phenological age and stock plant nutrition. Sensitivity to applied auxin is important both practically and for understanding the physiology of root formation. Applying optimal auxin concentrations is often the key to successful cutting propagation. Auxin dose-response curves for rooting usually show increased rooting with increasing auxin concentration to an optimum, followed by rooting inhibition and phytotoxicity at supra-optimal rates. These curves will be used to analyze dose response kinetics for common rooting hormones and carrier formulations. Dose-response curves were developed, using cuttings of *Ilex glabra* - inkberry holly, to evaluate IBA and NAA dissolved in 50% aqueous ethanol (EtOH) or 40% aqueous polyethylene glycol (PEG). Few differences were evident in the response curves of auxin dissolved in EtOH or PEG at concentrations of 0 to 75 mM. PEG yielded higher root numbers at the optimal concentrations of 10-20 mM NAA and 30-50 mM IBA. Both the stimulation and inhibition of rooting were more sensitive to NAA than IBA. Decreasing root length and increasing basal rooting inhibition were good indicators of auxin toxicity. These results further our knowledge of carrier effects on rooting and the potential of dose response analysis for studying adventitious root formation in cuttings.

517
AUXIN INFLUENCES ROOT INITIATION AND DEVELOPMENT FOR CHIONANTHUS RETUSUS STEM CUTTINGS
D. Joseph Eakes*, Charles H. Gilliam and Gary J. Keever, Department of Horticulture, Auburn University, AL 36849-5408

Terminal stem cuttings, 15.24 cm in length, of Chionanthus retusus Lindl. & Paxt. (Chinese Fringetree) were taken on 24 Sept. 1992. All cuttings were made from hardened off current years spring growth. The basal end of the cuttings were cut at an angle and treated with one of eight treatments before being stuck in a 100% vermiculite medium and placed under intermittent mist with a polyethylene covering. Treatments were: 3,000, 8,000 and 16,000 ppm IBA as K-IBA liquid quick dips and as commercial talc preparations (Hormex Nos. 3, 8 and 16), 10,000 ppm NAA as a quick dip, and an untreated control. Cuttings were harvested and evaluated on 10 Dec. 1992. All auxin treatments increased rooting %, average root length, total root fresh weight, and root rating when compared to the untreated control. Cuttings treated with 10,000 ppm NAA had the greatest rooting %, longest average root length, greatest root number, and highest root rating compared to the other auxin treatments, with the exception of the 16,000 ppm K-IBA quick dip treatment which was similar.

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685 (PS 5)

DETERMINATION OF CAUSAL RELATIONSHIP BETWEEN PHOSPHORUS AND BRACT EDGE BURN OF POINSETTIAS

Robert Eddy*, Brian Whipker and P. Allen Hammer, Department of Horticulture, Purdue University, West Lafayette, IN 47907-1165

Increasing rates of triple superphosphate added to the root media have a positive correlation with bract edge burn on poinsettias (Whipker, Hammer,1992). We have studied the effects of application of increasing rates of phosphorus supplied from multiple sources. Analysis of P content and other elements were conducted on root media and foliar samples to determine source of toxicity.

*Euphorbia pulcherrima* Willd. cultivars Dark Red Hegg and Red Sails were potted on September 8, 1992 in a root medium of peat, perlite and soil (40:40:20, v/v) mixture amended with N, K, Ca and micronutrients. Prior to potting, the root media were also ammended with either .30, 2.37 or 4.75 kg P/m$^3$ of superphosphate (0-18-0) or triple superphosphate (0-46-0). Two additional treatments of 75 mg P/liter and 150 mg P/liter supplied via 75% technical grade phosphoric acid in the irrigation system were also studied. Foliar samples were analyzed for N, P, K, Mg, Ca and flouride every two weeks after the start of short days. Root media samples were also collected and analyzed for pH, SS, $NO_3$, $NH_4$, P, K, Mg and Ca. Plant height, leaf dry weight and stem dry weight were measured on each sampling date as well as bract diameter and bract edge burn count at anthesis.

Media P levels increased as phosphorus rate increased for all P sources. By the second sampling date, severe toxicity symptoms developed on foliage of the 4.75 kg P/m$^3$ rate of superphosphate. This toxicity corresponded to high media P levels. Bract burn count at anthesis increased significantly at rates of 2.37 and 4.75 kg P/m$^3$ of both superphosphate and triple superphosphate. The highest incidence of bract burn (21.875 bracts burned/plant) occured with application of 2.37 kg P/m$^3$ of triple superphosphate.

686 (PS 5)

PHOSPHORUS FERTILIZATION OF ALSTROEMERIA FOR CUT FLOWERS

George C. Elliott*, Linda L. Madson and Mark P. Bridgen, Dept. of Plant Science, Univ. of Connecticut, Storrs, CT 06269-4067

*Alstroemeria xhybrida* 'Parigro Pink' divisions planted in 1 peat: 1 granulated rockwool medium were grown in a greenhouse maintained at 10 C minimum night temperature. Fertilizer solution containing 10 mM $KNO_3$, 5 mM $NH_4NO_3$, 5 mM $Ca(NO_3)_2$, 1 mM $MgSO_4$, 20 µM Fe, 10 µM Mn, 20 µM B, 2 µM Zn, 1.5 µM Cu, and 1.0 µM Mo, plus 0, 0.15, 0.30, 0.6, 1.2 or 2.4 mM $KH_2PO_4$, with 0 to 1.2 mM $K_2SO_4$ used to balance $K^+$, was applied at 7 to 10 day intervals. Plants were irrigated with tap water as needed between fertilizer applications. Plants supplied 2.4 mM P produced approximately 20% more total flowers and 33% more grade 1 flower stems (total length at least 80 cm, and bearing 4 or more cymes per stem) than plants supplied 1.2 mM P, and more than 4 times as many grade 1 flowers as plants supplied 0.3 mM P or less. In leaf tissue samples comprising the uppermost leaves of flowering stems, P concentration tended to increase with P supply but to decrease with time. During the period from 60 to 120 days from first harvest, tissue concentrations in the range 3.3 to 4.1 mg P / g dry wt were associated with highest yield.

687 (PS 5)

STAGE OF DEVELOPMENT AFFECTS NUTRIENT UPTAKE IN FOUR SNAPDRAGON CULTIVARS

Teresa M. Hood*, Harry A. Mills and Paul A. Thomas, Department of Horticulture, University of Georgia, Athens, GA 30602

Nutrient uptake by Antirrhinum majus L. 'Apache', 'Jersey City', 'Peoria', and 'Philadelphia' was compared at three developmental stages: Stage I, vegetative to bud initiation; Stage II, bud initiation to visible bud; and Stage III, visible bud to anthesis. Significant differences in uptake occurred between one or more developmental stages for all nutrients tested ($NO_3^-$, $NH_4^+$, B, $Ca^{++}$, $Cu^{++}$, $Fe^{++}$, $K^+$, $Mg^{++}$, $Mn^{++}$, $Mo^-$, P, and $Zn^{++}$). Uptake of the majority of nutrients increased or remained high during Stage III. These results indicate that the current cultural practice of stopping fertilization at bud elongation should be reexamined. Differences in uptake between cultivars were found only for $NO_3^-$ as uptake by 'Apache' was significantly higher than uptake by 'Philadelphia'.

688 (PS 5)

Peat-based Potting Media is an Extraneous Source of Iron When Using an Iron Chelate.

Gary R. Bachman* and Mary C. Halbrooks, Department of Horticulture, Clemson University, Clemson,SC 29634-0375.

The use of an iron chelate, Fe-DTPA, has been associated with an Fe toxicity disorder affecting the leaves of cutting geranium, *Pelargonium* x *hortorum*. In previous research Fe concentrations in medium leachates were higher than applied Fe-DTPA. The blank chelate DTPA has been shown to be an effective extractor of micronutrients from soilless media. Plants were grown in a controlled environment chamber at 22C and 16HR photoperiod, in a peat-based medium. In experiment 1 treatments of 0, 0.2 and 2 mM DTPA were applied to the growth medium and in experiment 2 treatments of 0, 0.02 and 0.2 mM DTPA and Fe-DTPA were used. Tissue and leachates were analyzed for Fe concentrations. Leachates of experiment 1 revealed that 2 mM DTPA extracted up to 1.79 mM Fe for the first week and then decreased to 0.3 mM while 0.2 mM DTPA extracted Fe in concentrations that generally increased during the experiment to 0.3 mM. In experiment 2 leachate concentrations of Fe from the 0.02 mM DTPA and Fe-DTPA treatments were similar and increased from 0.02 mM to 0.035 mM. The 0.2 mM Fe-DTPA increased from 0.14 mM to 0.26 mM while the 0.2 mM DTPA decreased from 0.17 mM to 0.054 mM. The 0 treatment of both experiments had 0.0027 mM Fe in the leachates. The tissue analysis of experiment 1 was inconclusive. Experiment 2 revealed no differences in weight and no difference in the total amount of Fe accumulated by the plants. This indicates that the practice of using Fe-DTPA, which increases the amount of potentially available Fe, may be a causal factor in geraniums accumulating toxic levels of Fe.

689 (PS 5)

IRON DISTRIBUTION AND THE OCCURRENCE OF AN IRON PHYSIOLOGICAL DISORDER IN MARIGOLD

Joseph P. Albano* and William B. Miller, Horticulture Department, Clemson University, Clemson, SC 29643-0375

The objective of this experiment was to study Fe distribution patterns in marigold (*Tagetes erecta* L., cv First Lady). Previous experiments have identified 'First Lady' as an Fe-sensitive cultivar. Plants were grown in a commercial peat-based media. Treatments consisted of 0, 17.9 and 179 µM Fe-DTPA added to a modified Hoagland's solution. In the presence of excess Fe, 'First Lady' developed a speckled pattern of chlorosis and/or necrosis of recently matured, primary leaves associated with downward leaf curl and/or cupping. Hereafter the disorder is referred to as "Bronze Speckle". Plants treated with 179 µM Fe-DTPA developed symptoms of "Bronze Speckle" with symptom severity increasing with leaf age and Fe concentration. Plants of the 0 and 17.9 µM treatments did not develop "Bronze Speckle", however Fe concentrations varied by treatment and tissue. Iron concentration in roots increased with Fe-DTPA treatment. Treatments had no effect on plant height or axillary and primary flower bud production.

690 (PS 5)

GENETIC DIVERSITY IN POPULATIONS OF NATIVE GRASSES AND FORBS IN MINNESOTA

Kerstin Concibido* and Mark S. Strefeler, University of Minnesota Department of Horticultural Science, 305 Alderman Hall, 1970 Folwell Avenue, St. Paul, MN 55108

The Legislative Commission on Minnesota Resources initiated a program to develop a viable seed industry for the production of native grasses and forb. A part of this program is to measure the amount of genetic diversity among and between populations in Minnesota. This information will be used to develop strategies for the distribution of seed in land reclamation and for management of seed production to maintain the genetic diversity of commercial seed lots. Two grasses, *Andropogon geradii* and *Schizachyrium scoparium*, and two forbs, *Monarda fistulosa* and *Liatris* sp., were used in this study. Genetic diversity of populations was measured using morphological traits and isozyme analysis of 30 to 50 individuals from each of the 13 to 49 populations. Thirteen enzymes systems were examined to detect polymorphisms. Isozyme polymorphisms have been detected in Liatris populations for PGM, MDH and ACP. No isozyme polymorphisms have been detected in grass populations. Morphological characteristics were measured in a common nursery to remove genotype x environment interactions. Variation in height, number of stems and number of inflorescences were observed within and among grass populations. Liatris populations varied in leaf number, width and length and shoot dry weights.

691 (PS 5)

INHERITANCE OF QUALITATIVE TRAITS IN NEW GUINEA *IMPATIENS*

Robert-Jan W. Ouené* and Mark S. Strefeler, University of Minnesota Department of Horticultural Science, 305 Alderman Hall, 1970 Folwell Avenue, St. Paul, MN 55108

New Guinea impatiens have been growing in popularity as a potted, bedding and hanging basket plant. This growth has been due mainly to the development of new cultivars by commercial breeding programs. However, no one has investigated or reported the inheritance of simple Mendelian traits of economic importance.

A study of the genetics of six qualitative traits was undertaken to elucidate inheritance of these traits in New Guinea impatiens. The traits studied were flower color, flower size, leaf color, leaf vein color, leaf variegation and variegation of leaf margins. Thirteen genotypes were used as parents in reciprocal crosses of all possible combinations. Fourteen



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# 211 ORAL SESSION 57 (Abstr. 499–505) Floriculture: Postharvest Physiology

499
LOW-TEMPERATURE STORAGE OF ALYSSUM, VINCA, NEW GUINEA IMPATIENS, AND TUBEROUS BEGONIA PLUGS
Royal D. Heins* and Thomas F. Wallace, Jr., Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

Alyssum, vinca, New Guinea impatiens, and tuberous begonia seedlings in plug cells were stored in coolers to determine the effects of temperature, light, and storage time on growth and forcing time of seedlings after transplanting. Optimum storage temperatures for each crop were also determined. Photosynthetic photon flux densities of 0, 1, and 5 $\mu$mol $m^{-2}$ $s^{-1}$ were combined with temperatures of 0.0, 2.5, 5.0, 7.5, 10.0, and 12.5C to create 18 storage environments. Sample plants were removed from each treatment at 1-week intervals for 6 weeks, and were forced into flower. Temperatures of 5°C or less caused chilling injury on New Guinea impatiens and vinca. No chilling injury occurred on Alyssum at any temperature while chilling injury occurred on tuberous begonia after 3 weeks at 0C. Flowering of New Guinea impatiens and vinca was not delayed on plants not damaged by chilling injury. Increasing duration of dark storage resulted in flowering delay of alyssum and tuberous begonia. As dark-storage duration increased, alyssum plants elongated, etiolated, and then died. In general, all plants stored better in the light than in darkness. Optimal storage temperatures were 0-5C for alyssum, 7.5-12.5C for vinca and New Guinea impatiens, and 5 to 7.5C for tuberous begonia.

500
ACCLIMATIZATION OF *CHRYSALIDOCARPUS LUTESCENS* WENDL.
Trinidad Reyes*, Terril A. Nell, and James E. Barret, Environmental Horticulture Department, University of Florida, Gainesville, FL 32611

A 3x3 factorial experiment in a split-plot design was conducted to evaluate interior performance of *Chrysalidocarpus lutescens*. Treatments included three irradiance levels (481, 820 and 1241 $\mu$mol $m^{-2}s^{-1}$) and three fertilizer rates (440, 880 and 1660 mg/23-cm pot, weekly). Plants were grown for 8 months under greenhouse conditions. Afterwards, plants were placed indoors (20 $\mu$mol $m^{-2}s^{-1}$ for 12 hr daily, 21 ± 1C and relative humidity of 50 ± 5%) for 3 months. At the end of the production phase, light compensation point (LCP) varied from 243 $\mu$mol $m^{-2}s^{-1}$ at the high irradiance level to 140 at the low irradiance level. Dry weight and nonstructural carbohydrates were lower and chlorophyll content was higher as irradiance levels were reduced. Increasing fertilizer to the highest rate decreased dry weight and nonstructural carbohydrates. After 3 months indoors, LCP declined to 126 $\mu$mol $m^{-2}s^{-1}$. Number of fronds increased in all treatments at the expense of reserved carbohydrates. However, the drastic carbohydrate depletion observed after the interior holding period (97% in stem starch and 62% in root starch ) indicates that *C. lutescens* is not a species for extended use under very low interior conditions.

501
FACTORS ASSOCIATED WITH REDUCED POSTPRODUCTION QUALITY OF CHRYSANTHEMUM FOLIAGE PRODUCED UNDER HIGH NUTRITIONAL REGIMES
Stephen A.Carver* and Harry K. Tayama, Dept. of Horticulture, The Ohio State University, Columbus, OH 43210.

*Dendranthema grandiflora* Tzvelev., 'Spirit' and 'Torch' were produced under three water-soluble fertilizer (WSF) and one controlled-release fertilizer (CRF) regimes, with or without weekly $CaCl_2$ sprays during the last three weeks of production to evaluate their influence on postproduction foliar longevity. Foliage of plants produced with 400 mg·liter$^{-1}$ N (Peter's 20N-4.4P-16.6K) declined 1 to 2 weeks earlier than those produced with 400 mg·liter$^{-1}$ N (Hydro-sol + $NH_4NO_3$), and 3.5 to 5 weeks before plants fertilized with 100 mg·liter$^{-1}$ N (Hydro-sol + urea + $NH_4NO_3$) or 1 kg N·meter$^{-3}$ growing medium (Osmocote 14N-6.2P-11.6K). Calcium chloride had no influence on foliar longevity. Plants receiving either 400 mg·liter$^{-1}$ N treatment were generally larger (plant height and diameter), fuller (total and average leaf area), more vigorous (leaf dry weight per unit leaf area), and darker green in color ('Spirit' only, chlorophyll content per unit leaf area). Plant receiving WSF treatments had less than 0.5x the root system (dry weight) of CRF plants at harvest. Postproduction foliar longevity was most significantly and consistently correlated with foliar and growing medium nitrogen content. Relationship of postproduction foliar longevity with leaf soluble protein, carbohydrate, and starch content will be presented.

502
SUPPLEMENTAL SUCROSE INCREASES LONGEVITY OF MINIATURE POTTED ROSE FLOWERS
José A. Monteiro*, Terril A. Nell and James E. Barrett, Department of Environmental Horticulture, University of Florida, Gainesville, FL 32611.

Potted 'Orange Sunblaze' miniature roses, were grown under long days by night interruption from 2200 to 0200 HR. Flowering plants were moved to interior conditions (12 $\mu$mol $s^{-1}$ $m^{-2}$ from cool white fluorescent lights for 12 hr daily and 21 ±1C) when buds were showing color and sepals were beginning to unfold. A needle connected to a reservoir containing either water or a 3% sucrose solution was inserted into stems. One flower bud was selected on each plant and other buds and open flowers were removed. Flower longevity and amount of solution/water uptake were recorded. Flowers of plants receiving sucrose lasted 2 days longer than flowers receiving water (P=0.015) with longevities of 15 and 13 days for sucrose and water, respectively. Research is being completed to relate solution uptake to respiration and flower longevity. These data show that supplemental sucrose increases flower longevity in potted plants, similar to results with cut flowers.

503
EFFECTS OF LOW $O_2$ ON SENESCENCE OF CARNATION FLOWERS (*DIANTHUS CARYOPHYLLUS* L. cv. ELLIOTT'S WHITE)
Theophanes Solomos*, Department of Horticulture, University of Maryland, College Park, MD 20742-5611

Additions of adjuvants which inhibit the biosynthesis or action of $C_2H_4$ show that the climacteric rise in respiration during senescence of cut carnations is a facet of ethylene action and not senescence as such. The rate of $CO_2$ output of carnation flowers was diminished in a dose-dependent mode by low $O_2$. The data indicate that the diminution of respiration by low $O_2$ may not be attributed to the restriction of either of the mitochondrial terminal oxidases. The steady-state concentration of ATP was similar in both air and 2% $O_2$-treated flowers. 2% $O_2$ eliminated for 32 days any rise in $C_2H_4$ evolution. In addition the longevity of the flowers kept under 2% $O_2$ was longer than those which were treated with STS. The results are taken to indicate that hypoxia affects developmental events leading to the induction of $C_2H_4$ and/or the synthesis of transducer of $C_2H_4$ action.

504
ACTIVITY OF ADH AND ETHANOL PRODUCTION IN CARNATION FLOWERS TRANSFERRED TO $N_2$ FROM AIR AND LOW $O_2$
Xiuhua Chen* and Theophanes Solomos, Department of Horticulture, University of Maryland, College Park, MD 20742-5611.

Freshly harvested carnation flowers (*Dianthus caryophyllus* L. cv. White's Sim) were kept for 4 days either in air or low $O_2$ before they were transferred to $N_2$. Low $O_2$ in the range of 1.2-2.7% resulted, depending on the concentration, in a decrease in respiration and 3-5 fold increase in alcohol dehydrogenase (ADH) activity, without a concomitant increase in ethanol production. Anoxia initially, within 4 hours, depressed by about 40% the rate of $CO_2$ evolution in air, but had no effect on low $O_2$-treated flowers. Anoxia induced in all treatments an increase in the activity of ADH, but the levels of ADH were 1.5 fold higher in the low $O_2$-treated flowers than those kept in air. This difference increased to 10-fold after 6 days because by then, the air treated flowers were almost dead. Prior exposure to hypoxia enhanced the anoxic life of flowers by 3-4 days. Anoxia also induced an increase in ethanol production in both air and low $O_2$ treated flowers. The peak value of ethanol evolution was about 1.5-fold higher in the low $O_2$ than in air-treated flowers. The data are discussed in terms of the effect of hypoxia on carnation flower metabolism and longevity.

505
INHIBITION OF ETHYLENE BIOSYNTHESIS AND ACTION IN CUT CARNATION FLOWERS BY AMINOTRIAZOLE
Steven A. Altman* and Theophanes Solomos, Department of Horticulture, University of Maryland, College Park, MD. 20742

Treatment of carnation flowers (Dianthus caryophyllus L., cv Elliot's White) with 50 or 100 mM aminotriazole (ATA) for 4 days postharvest results in suppression of the respiratory climacteric and significant extension of vase life. ATA inhibited ethylene evolution and the ethylene climacteric via inhibition of the biosynthesis of ACC synthase. The inhibitory effects of ATA increased with time of exposure and concentration. Flowers treated with 50 or 100 mM ATA for 2 days exhibited a dose dependent climacteric

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699 (PS 5)

VAM INNOCULATION OF SUDEX USING PRAIRIE REMNANT SOIL

Kemery, Ricky D.* Purdue University Horticulture Dept. 1165 Horticulture Bldg. West Lafayette, IN. 47907-1165

Soil samples collected from four remnant prairie plant communities in Indiana were used as innoculum for pot cultures of Sudan grass seedlings (*Sorghum sudanense*). The growth of seedlings was correlated with the quality of the prairie remnant; the less degraded sites provided innoculum which resulted in the most vigorous plant growth in culture. Sudan grass root segments were harvested and prepared for assay of vesicular-arbuscular mycorrhizae. VAM was shown to be present in innoculated samples. Results indicate that soil collected from undisturbed prairie remnants may provide a better source of VAM innoculum for larger scale production of plants which associate with VA mycorrhizae.

700 (PS 6)

WINTER ANNUAL LEGUMES AND GRASSES AS MULCHES FOR SUSTAINABLE AGRICULTURAL PRODUCTION OF FRESH-MARKET TOMATOES

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

Hairy vetch, crimson clover, and rye, separately or in combination, were grown in the fall as cover crops and mowed in the spring to form an organic mulch in a no-tillage sustainable agricultural system for production of fresh-market tomatoes (*Lycopersicon esculentum* Mill, cv 'Sunny'). Fruiting earliness, yield, and size were compared between the organic mulch treatments and those under bare soil, paper and black polyethylene mulches. Fruiting was about 9-10 days earlier under black polyethylene mulch than all other treatments. Total marketable yields ($t \cdot ha^{-1}$) under the mulch treatments were: hairy vetch, 85; hairy vetch plus rye, 69; crimson clover, 66; black polyethylene, 44; bare soil, 36; and Horto paper, 30. Average fruit size was significantly larger in all organic mulch treatments than in bare soil, Horto paper, and black polyethylene mulches. Early growth of tomato plants was highest with plastic but subsequent growth was highest with hairy vetch. Superior vigor with hairy vetch was probably the result of higher nitrogen concentration of vetch residue relative to the other cover crops.

701 (PS 6)

POTENTIAL OF NO-TILL TOMATO PRODUCTION IN TENNESSEE

R. Allen Straw*, Charles A. Mullins, and David L. Coffey, The University of Tennessee, Plateau Experiment Station, Rt. 9, Box 363, Crossville, TN 38555

No-till (NT) culture has worked well with many agronomic crops; however, NT culture has been less successful with vegetable crops. 'Mountain Pride' tomatoes were grown under (NT) and conventional-till (CT) culture at the Plateau Experiment Station. During the first two years of the study, both NT and CT plots were tilled in the fall and sowed in a winter wheat cover crop. In the third year of the study, a continuous NT culture was maintained. Tomato yields were identical from the two tillage practices in the first year. In the second year, yields were significantly higher from NT tomatoes than CT tomatoes. The trend reversed in the third year with CT producing significantly more yield than NT culture. In addition, NT tomato plants were stunted and roots were observed to grow laterally near the soil surface. Production of NT tomatoes following a winter wheat cover crop appears feasible; however, continuous NT was not promising.

702 (PS 6)

EFFECT OF PLANTING DATE AND CULTIVAR ON PROCESSING SWEET CORN PRODUCTION IN TENNESSEE

Charles A. Mullins*, R. Allen Straw, and N. Bill Shamiyeh, The University of Tennessee, Plateau Experiment Station, Rt. 9, Box 363, Crossville, TN 38555

Six processing type sweet corn cultivars were evaluated for productivity and production problems at eight planting dates at the Plateau Experiment Station at Crossville, TN. Plant size and yields declined rapidly after the fourth planting date. During this period soil moisture was adequate and temperatures were relatively cool, therefore, plant growth responses may have been attributed to day length or light interception. Insect populations and insect damage increased as the harvest season progressed. 'Reveille' had poor ear fill throughout the season, while percentage ear fill of all of the other cultivars, with the exception of 'More', decreased rapidly after the fourth planting date. 'More' plants were the most vigorous throughout the trial. 'More' was one of the most productive cultivars throughout the season and especially at the later planting dates.

703 (PS 6)

TILLAGE, COVER AND ALLELOPATHIC EFFECTS ON BROCCOLI.

W.T. Kelley*, University of Georgia, Department of Horticulture, Tifton, GA 31793 and D.L. Coffey, University of Tennessee, Department of Plant & Soil Science, Knoxville, TN 37901-1071.

'Packman' hybrid broccoli was grown under three tillage systems at three locations in 1989 and 1990 to study the feasibility of no-till production. Tillage systems consisted of 1) conventional tillage with no winter cover, 2) conventional tillage with wheat winter cover, and 3) no-till transplanted directly into paraquat killed wheat cover. Locations were at Knoxville, Greeneville and Crossville, TN. Yield, value and marketability of broccoli was significantly reduced in no-till vs conventional tillages. The possibility that small grain cover crops have a deleterious effect on broccoli growth was then investigated. Broccoli was grown in greenhouse pots with solutions of ferulic, syringic, p-coumaric, p-hydroxybenzoic and vanillic acids at 1, 10, 100 and 1000 $\mu$M concentrations and compared to controls which received only water. Shoot dry weight and plant height were both reduced with increasing acid concentrations. Soil samples were taken from field plots in 1990 and analyzed for levels of these acids using HPLC. Soils with higher levels of mulch had higher levels of ferulic and p-coumaric acid, but similar levels of the other acids. Allelopathic effects of the cover crop is a potential cause of reduced broccoli yields under no-till conditions.

704 (PS 6)

EFFECTS OF PHOTOPERIODS ON GREENHOUSE TOMATO AND PEPPER PRODUCTION

Dominique-André Demers*, Martine Dorais, Serge Yelle and André Gosselin, Centre de recherche en horticulture, Département de phytologie, Université Laval, Ste-Foy, Québec, Canada, G1K 7P4.

Most works on artificial lighting of winter greenhouse vegetable crops studied the effects of photosynthetic photon flux but rarely photoperiod. Over the last three years, we conducted experiments to find out the best photoperiods for production of greenhouse tomato and pepper. We found that extending photoperiod up to 20 hrs increased productivity of pepper plants while continuous light (24 hrs) decreased yields. For tomato plants, productivity reached a maximum under a 14-hr photoperiod while longer photoperiods (16 to 24 hrs) did not increase yields. For both pepper and tomato plants, optimal growth (shoot fresh and dry weights) was obtained under the same photoperiods that gave the best productivities. We also observed leaf chloroses on tomato plants after 6 weeks under photoperiods of 20 and 24 hrs and leaf deformations (wrinkles) on pepper plants exposed to continuous lighting. We also observed that plants under continuous light grew better and flowered earlier during the first 5 to 7 weeks of treatments. So, tomato and pepper plants can use advantageously continuous supplemental lighting for a short period of time but are negatively affected on a long term basis. Future works should look at varying photoperiods to optimize yields.



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487

CARBOHYDRATE COMPOSITION OF PLANT ORGANS AND LEAF DIURNAL CARBOHYDRATE FLUCTUATION IN SNAPDRAGON

Ricardo Campos* and William B. Miller, Department of Horticulture, Clemson University, Clemson, SC 29634-0375.

The objective of this work was to determine the carbohydrate composition of snapdragon (*Anthirrinum majus* L.) organs, and the diurnal carbohydrate fluctuation in leaves. Particular interest was in mannitol, a polyol that occurs in snapdragon. Mannitol was present in all organs; its concentration was highest in shoot tips (68 mg/g dw) and lowest in roots (12 mg/g dw). Mature flowers had the highest soluble carbohydrate concentration (328 mg/g dw) and roots the least (45 mg/g dw). Starch concentration varied from 15 to 60 mg/g dw. An undetermined sugar was found in all organs. In the diurnal study, conducted in the greenhouse, the undetermined sugar had the highest concentration at midnight and the lowest at noon. In vegetative plants, total soluble carbohydrates and starch were highest at 9 and 6 pm, respectively; whereas in reproductive plants, they were highest at midnight and 9 pm, respectively.

488

STEM ELONGATION IN 'CARA MIA' ROSES

Francisco Bravo-Plasencia* and J. Heinrich Lieth, Environmental Horticulture, University of California, Davis, CA 95616-8587.

Stem length of cut flower roses is one of the primary determinants of the sales price. Thus knowledge of the process of shoot elongation is useful in optimization of rose production. In this study shoot elongation was investigated by continuously logging 'Cara Mia' rose shoot length using linear displacement position sensors (LDPS). Under natural conditions, elongation was found to occur mainly at night. The objective of this study was to investigate the role of environmental factors on rose stem elongation and to determine whether the process was related to an endogenous circadian rhythm or the absence of light. Measurements were made under various photoperiodic conditions (0, 8, 10, 12 and 24 hours night) and various temperature regimes. Under alternating light/dark regimes, regardless of photoperiod, shoot elongation rates follow a cyclical pattern with maximum values during dark periods and lower rates during periods of light. The elongation rate declined abruptly with the beginning of the light, suggesting that phytochrome activity might be responsible for this cessation of elongation. Under continuous light and constant temperature, the cyclical behavior was also observed, although the amplitude of the rhythm was smaller than under continuous light.

489

A FORCING PROGRAM FOR ISRAELI-GROWN LEUCOJUM AESTIVUM AS POTTED PLANTS

A.A. De Hertogh, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Over 3 years, greenhouse and phytotron trials were conducted using Israeli-grown Leucojum aestivum. The objective was to evaluate the potential of this bulb as a potted plant for North American forcing. It was found that bulb sizes of 12/14, 14/16, and 16/up cm (in circumference) produced quality plants. Bulbs of 10/12 cm had reduced number of florets per floral stalk. The optimal cold requirement was 15-19 weeks. The major physiological disorder associated with forcing was flower abortion. Phytotron studies showed that this occurred readily at 30/26 C (Day/Night temperatures) and was minimal at 18/14 C. When >12 cm bulbs were properly programmed and forced in the greenhouse, they produced plants that were 25-35 cm tall at flowering, with 1-2 floral stalks and 4-6 florets per stalk. No plant growth retardants are required for forcing this bulb as a 15 cm diameter potted plant.

490

CHARACTERIZATION OF THREE SOLUBLE INVERTASES FROM *LILIUM LONGIFLORUM* FLOWER BUDS

William B. Miller and Anil P. Ranwala*, Department of Horticulture, Clemson University, Clemson, SC 29634-0375

Three soluble invertases (EC 3.2.1.26) previously identified in developing flower buds of *Lilium longiflorum* Thunb (HortSci. 25:1076, 1990) have been further investigated. These enzymes are fully separable on DEAE-Sephacel and differ substantially in enzymological properties. Each enzyme was further purified by consecutive use of Sephacryl S-200 gel filtration, Con A Sepharose affinity chromatography and Phenyl-Agarose hydrophobic interaction chromatography. This produced 135, 189 and 202 fold purification of invertase I, II and III, respectively. Each was an acid invertase showing pH optima between 4.0 and 5.0. The molecular weight of each invertase was estimated to be 75,000 Da by gel filtration. Invertase I, II and III showed temperature optimum at 40, 50 and 45°C, respectively. A temperature stability study revealed that Invertase III was the most stable followed by II and I. Invertase I, II and III had Km values of 1.0, 6.4 and 6.6 mM for sucrose, respectively. Invertase II and III had lower affinity to raffinose and stachyose than Invertase I. All three invertases were completely inhibited by $Hg^{2+}$ and $Ag^{+}$ ions at 1.7 mM concentration. At this concentration $Cu^{2+}$ inhibited 45% of activity of Invertase I, but only 30% of activity of Invertase II and III.

## 210 ORAL SESSION 56 (Abstr. 491–498) Vegetable Crops: New Crops

491

LETTUCE FOR PROCESSING IN LATIN AMERICA: A *McGROWING* PROBLEM FOR THE FAST FOOD INDUSTRIES

Dennis R. Decoteau* and Margaret J. McMahon, Department of Horticulture, Clemson University, Clemson, SC 29634-0375

Latin America is targeted as one of the most rapidly growing areas for expansion for McDonald's International. For example, McDonald's opened its first store in Mexico in 1985 and now has over 50 stores in that country. McDonald's is projecting to have over 100 stores in Mexico by the year 2000. Producing vegetable crops in the same country as a store is desirable to reduce shipping problems and to enhance vegetable production within the country. Problems with lettuce in Latin America include field production (poor growth and yields) and postharvest processing and handling (short shelf life). Beginning in 1992, field studies in cooperation with McDonald's International and Asgrow Seed Company were established in three field sites in Mexico and one site in Panama to determine seasonal uses of varieties (Mexico and Panama) and sites (Mexico) in order to provide quality year round production of lettuce for processing. Results suggest that varieties acceptable for trade in fresh market may not have desirable characteristics during processing (color and cut) and storage (shelf life and odor). In addition, the introduction of new varieties may be needed for year-round production.

492

DEVELOPING A SMALL-SCALE, LOW-INPUT CULTURAL SYSTEM FOR ELEPHANT GARLIC, A SPECIALTY CROP

Jeanine M. Davis*, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695

Elephant garlic (*Allium ampeloprasum* L.), which is not a true garlic, produces large bulbs with mild-flavored cloves. It is a high-priced specialty vegetable which is sold as individual bulbs or in multi-bulb decorative braids. The crop is of interest to small-scale growers because it is planted in the fall and harvested in mid-June, making it suitable for use in a multi-crop production system. Since 1989 studies have been conducted to develop a small-scale, low-input cultural system for elephant garlic. Organic versus synthetic fertilization, planting stock clove size, planting date, nitrogen rate, mulches, and multi-row plantings have been examined. Cloves have not been planted in the same field twice to avoid any soil-borne pest problems. There have been no diseases or insects and weeds have been managed with shallow cultivation. High yields of large, high-quality bulbs have been obtained by planting stock cloves greater than 20 g in mid-October and spacing them 20 cm apart in the row. A total of 140 kg N per hectare has been applied in three split-applications. Yields have averaged over 50 kg per 100 linear meters of row. Bulbs are cured by air-drying for six weeks.



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712 (PS 6)

## BITTER GOURD: A POTENTIAL CROP FOR SMALL FARMS

Wayne F. Whitehead* and Bharat P. Singh, Agricultural Research Station, Fort Valley State College, GA 31030-3298

A preliminary study on bitter gourd, *Momordica charantia* L., an exotic crop grown extensively in China and India for consumption and medicinal purposes was conducted during summer 1992. The objective of the investigation was to determine the potential of bitter gourd as an alternate corp for small farm production. On May 21, seeds were planted on hills 3 m apart. A 1.65 m high chicken-wire trellis was erected for trailing the crop. Observations on disease and insect incidence, flowering date, fruiting pattern and yield were recorded. The crop was disease free, but was infested with whitefly and stinkbug. Flowering started about 60 days after planting. The first harvest was made on August 10 and then continued three times a week for eight weeks. The fruit yield peaked during the sixth week of harvest. Average fruit length and diameter were 20 and 6 cm, respectively. Per plant average fruit number and fresh fruit weight were 87 and 12.9 kg, respectively. The preliminary results indicate that bitter gourd has a potential as an alternate crop for small farm vegetable production.

713 (PS 6)

## DETERMINATION OF OPTIMAL SPAN FOR PLANTING AMARANTH IN MIDDLE GEORGIA

Bharat P. Singh* and Wayne F. Whitehead, Agricultural Research Station, Fort Valley State College, Fort Valley, GA 31030-3298

Amaranth, *Amaranthus* spp., is a promising summer leafy vegetable for the Southern United States. Planting of greens is usually spread over a period of time to enable growers to supply the market on a continuous basis. This study was carried out to establish the time span for planting amaranth in Middle Georgia. *A.tricolor*, genotype "RRC 241" was planted in a randomized complete block experiment on six planting dates one month apart between 14 April and 14 September. Data on plant height, photosynthetic rate and green fresh weight were collected 40 days after planting. June, July and August plantings had similar plant height, which was significantly greater than other planting dates. The plants from June seeding had the highest photosynthetic rate of 25.2 μmol $m^{-2}$ $s^{-1}$. Green yields from April, May, June, July, August and September plantings were 0, 0.1, 9.1, 7.4, 5.7 and 2.5 Mg $ha^{-1}$, respectively. It was inferred that June and July were the best months for planting amaranth in Middle Georgia.

714 (PS 6)

## RESPONSES OF MULCHED TOMATOES TO UNDER-BED TRENCHING AND PROCESSED MUNICIPAL WASTE APPLIED TO CALCAREOUS SOILS

H. H. Bryan* and C. J. Lance, TREC, IFAS, Homestead, FL 33031

Trenches 0, 25 and 50 cm deep (d) and 15, 30 and 45 cm wide (w) were dug, refilled, and bedded-over in 1985. Tomatoes were planted in 1985, '86 and '88. Daorganite processed sludge was initially applied broadcast; in 50 cm deep x 45 cm wide trenches; and in 45 cm wide strips on beds, and rototilled 10 cm deep at rates of 0, 6.7, 13.4, and 26.8 t/ha. Three subsequent annual applications were strip rototilled at 0.5x the above rates to determine effects of initial and residual rates on tomato yields. In 1989, 0 and 9 t/ha of Daorganite or Bedminster Bioconversions compost were applied in trenches 0, 12.5, 25 or 50 cm deep and 45 cm wide; and 0, 6.7, or 13.4 t/ha of each were strip rototilled. Inorganic fert. was applied at approx. 0.5x recommended rate. Yields of large and marketable fruit increased with increasing depth and width of trenches. Tomatoes responded best to 6.7 and 13.4 t/ha annual sludge applications, and to rototilled strips or trench placements of sludge. Yields of large and marketable fruit increased with increasing depth of trenches. Yields were higher with 9 t/ha sludge in trenches plus 6.7 or 13.4 t/ha sludge strip rototilled, and with 13.4 t/ha of either sludge or compost strip rototilled in the bed.

715 (PS 6)

## NITROGEN AND POTASSIUM FERTILITY OF JALAPENO PEPPER DURING PLANT DEVELOPMENT AFFECTS PLANT GROWTH AND FRUIT YIELD AND PUNGENCY

C. Johnson, J.R. Johnson, and D.R. Decoteau*, Dept. of Horticulture, Poole Agriculture Center, Box 340375, Clemson University, Clemson, SC 29634.

Nitrogen (N) and potassium (K) nutrition of Jalapeno peppers was determined on plants grown in sand culture. Varying rates of N (1 to 30 mM) and K (1 to 12 mM) in Hoagland's solution were evaluated to determine optimum nutrient concentration for plant growth and fruit production. Application of nutrient treatments were initiated at transplanting and flowering. A quadratic response to N rate was determined for biomass and fruit production per plant, regardless of when the N treatments were initiated. Plants that had N treatments initiated at transplanting were smaller and had less fruit. Optimum N rate for fruit yield was 15 mM. A linear response to K rate was determined for biomass, fruit number, and fruit weight per plant when nutrient treatments began at transplanting. A quadratic response to K rate was determined when K treatments began at flowering. Pepper plants that had K rates initiated at transplanting were smaller and had less fruit. The optimum K rates for fruit yield was 3 to 12 mM. Pungency of fruit was only affected by N rate treatments initiated at transplanting. 1 mM N reduced capsaicin levels in fruit as compared to other rates. Jalapeno peppers grown in sand culture required 15 mM N and at least 3 mM K for optimum fruit production.

716 (PS 6)

## INFLUENCE OF WINTER COVER CROPS AND NITROGEN FERTILIZER ON TOMATO AND BEAN PRODUCTION AND SOIL NITRATE DISTRIBUTION

Heather A. Haut*, Kathy H. Brock, and Dennis R. Decoteau, Dept. of Horticulture, Poole Agriculture Center, Box 340375, Clemson University, Clemson, SC 29634-0375 and Greg D. Hoyt, Dept. of Soil Science, NC State University, Mountain Horticultural Crops Research and Extension Center, Fletcher, NC 28732

Winter cover crops (wheat and crimson clover) in combination with three levels of nitrogen fertilizer (0, 6, 120 kg/ha) were evaluated as to their influence on bean and tomato production (fruit yield, disease and insect on fruit, and nutrient content of fruit and plants). The influence of cover crop and fertilizer on nitrogen distribution in the soil profile was determined for each treatment. A split plot design was used with the cover crop as the main treatment and nitrogen rate as the split treatment. Soil cores were taken in the spring before planting and at the termination of harvest each year. Results indicate that cover crop had an effect on non-marketable bean fruit, but did not affect marketable fruit harvested for both bean and tomato. Cracked and insect damaged tomato fruit was greatest in fallow and wheat treatment, and culls of bean fruit was greatest in the clover treatment. Cover crop treatment had no affect on overall tomato and bean plant nutrient content. Wheat and clover cover crop treatment reduced the amount of nitrate leaching in the soil profile as compared to the fallow. These results suggest that wheat and clover can be used effectively as cover crops to reduce nitrate leaching without affecting bean and tomato fruit yield.

717 (PS 6)

## Mechanical height control for tomato plug transplants: effects on yield

Thomas Björkman, Dept. of Horticultural Sciences–NYSAES, Cornell Univ. Geneva, NY 14456

Mechanical conditioning is an efffective method for limiting excessive stem elongation in tightly grown plants. It is particularly effective in tomatoes. Any treatment that reduces growth of transplants has the potential to also reduce subsequent growth, and thereby reduce yield. Giving plants 0, 10, 20 or 40 strokes daily showed a maximal height reduction with 20 strokes, but further reduction in leaf area with 40 strokes. The potential redution in growth rate was about 25%. Harsher treatment to provide greater growth control appears unproductive. For studying the effects of stroking on yield, 288-size transplants were grown as they would in commercial production, and 3 flats of each transplanted in grower-cooperators' fields in 1991 and 1992. There was no significant yield reduction in either year. In 1991, the stroked plants had more severe blossom end rot than the controls, resulting in about 1 kg/m more culls. The weather in each year caused low yields and high sample variation. When the plants experience less stress duiring the growing season, the transplant treatments would be expected to have a larger effect.

| | Control | Stroked | |
|---|---|---|---|
| 1991 | 10.7 ± 1.3[1] | 9.4 ± 1.6 | NS |
| 1992 | 4.3 ± 0.6 | 4.2 ± 0.4 | NS |

[1]Yield (kg/m) ± s.d.

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but separate source of N-K from the soil bed surface, all of which is protected by a full bed mulch. By shifting to the gradient-mulch system, Florida tomato growers more than doubled their yields and increased profitability by 40 to 60%. Conventional research efforts such as irrigation and fertilizer scheduling become irrelevant, along with measures of evapotranspiration and tensiometers; soil testing and plant tissue analyses can be de-emphasized and the many statistically designed experiments to evaluate nutrient levels have an outmoded nutritional validity. The shift of the gradient technology to a containerized concept has a maximum potential in the development of a globally sustainable production system. The failure to utilize these innovative paradigms limits the potential of nutritional research to advance beyond a level of mediocrity.

475

LIGHT AND NITROGEN LEVELS AFFECT THE AGRONOMIC PERFORMANCE OF VEGETABLE AMARANTH

D. J. Makus, USDA-ARS, Booneville, AR 72927

Three-week-old transplants of Amaranthus tricolor cultivars 'RRC 241' and 'Hinn Choy' were given split applications of supplemental N (0, 100 and 200 kg/ha). Five weeks after sowing both cvs. were exposed to 100, 70 and 50% of ambient solar radiation for nine and ten days, respectively. During shading, avg. daily photosynthetic irradiance was reduced from 11.6 to 7.7 and 5.0 KW/m$^2$, respectively. Soil, air, and leaf temperatures were reduced by shading. Plants were harvested in the seventh week. Cultivars differed in leaf number and area, yield, height, mineral uptake, and stem fresh and dry weight. Increasing shade levels decreased the dry wt. of stems, leaf blades, and plants. Shading had no effect on leaf area, plant fresh wt. or yield, but increased stem length, plant water content and leaf blade pigments. Photosynthetic fixation rates were reduced by 50% shade. Leaf blade protein and most leaf blade mineral nutrients, including nitrates, were increased by shading. Nitrogen application increased stem length, stem, leaf blade and plant fresh and dry wt., leaf blade pigments and yield.

476

WATERMELON SEEDLING GROWTH AND ROOT CALCIUM ABSORPTION AS INFLUENCED BY THE FUNGICIDES CAPTAN AND THIRAM

Aimin Liu*[1], Joyce G. Latimer[1], and Robert E. Wilkinson[2], Dept. of Horticulture[1], Dept. of Agronomy[2], Georgia Experiment Station, University of Georgia, Griffin, GA 30223-1797

Unilateral application of $Ca^{2+}$ and $Al^{3+}$ induced curvature in roots of 'Starbrite' watermelon [Citrullus lanatus (Thumb.) Matsum and Nakai] seedlings from both untreated and commercially pretreated seeds. In untreated seeds, PCMBS inhibited root curvature by decreasing $Ca^{2+}$ and $Al^{3+}$ uptake. In pretreated seeds, PCMBS only inhibited $Ca^{2+}$-induced root curvature. Captan and thiram inhibited $Ca^{2+}$- or $Al^{3+}$-induced root curvature. Captan showed the greatest inhibition of $Ca^{2+}$ uptake at 100 mg/liter, whereas thiram was most effective at 0.01 mg/liter. The effects of captan and thiram were statistically additive. Thiram appeared to show a similar mode of action to PCMBS in affecting $Ca^{2+}$ uptake. DDT reversed the inhibitory effect of thiram, but not that of captan.

Acid soil (pH 4.6) reduced number of leaves, leaf, stem, shoot and whole plant dry weight, and stem length. Pretreated seeds produced greater root dry weight and root:shoot ratio in acid soil than did untreated seeds. Fungicides may have reduced $Al^{3+}$ toxicity by inhibiting $Al^{3+}$ uptake in acid soil.

477

GENETIC ADAPTATION OF VEGETABLE CULTIVARS TO NUTRIENT-DEFICIENT SOILS.

John E. Bowen* and Patricia Macomber, Plant Molecular Physiology Dept., Beaumont Agric. Research Center, Univ. of Hawaii, Hilo, Hawaii 96720.

Cultivars of many vegetable crops; e.g., tomato and Chinese cabbage, differ genotypically in rates of uptake and accumulation of various essential nutrients. Indeed, selection of a nutrient-inefficient cultivar can cause crop failure. The physiology and kinetics of some of these differences have been studied. Excised tomato roots (Lycopersicon esculentum L.) cv Kewalo absorbed $Zn^{2+}$ and $Cu^{2+}$ much more rapidly than did cv Sel 7625-2. Uptake of each cation was competitively and reciprocally inhibited by the other. Root apices from the two tomato cvs did not differ in their affinities for $Zn^{2+}$ and $Cu^{2+}$, however. Vmax values for $Zn^{2+}$ and $Cu^{2+}$ uptake in cv Kewalo roots were three-fold greater than those for cv Sel 7625-2.

Chinese cabbage cvs Nozomi and Aichi have significantly higher requirements for B and K, respectively, than do 11 other cvs. Cv WR Green 60 requires more P and Ca but cv Nagaoka 50 has a significantly lower Mg requirement than the other cvs tested. No significant differences occurred among the 12 cvs with regard to their Zn, Mn and Cu requirements.

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## Cross-commodity: Chilling Stress

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LIPID CHANGES IN BELL PEPPER FRUIT DURING CHILLING AND REWARMING

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

Lipid composition and pigment content in bell pepper fruit that were freshly harvested, chilled 2 weeks at 2C (CH), or chilled then rewarmed to 20C for 4 days (RW), were determined. There was slight to moderate loss of glycerolipids during chilling, with much greater losses after rewarming. Loss of galactolipid (GL) exceeded that of phospholipid (PL). The ratio of the GL, MGDG:DGDG, did not change in CH and RW fruit, and there was no loss of chlorophyll or change in the Chl a:b ratio, but neutral carotenes declined ca 30 % after rewarming. Only small changes in total membrane sterols (TMS) were noted in CH and RW fruit, but major changes in sterol glycosylation and esterification occurred. The stigmasterol:sitosterol ratio increased during chilling and after rewarming. Due to PL loss, the ratios of TMS and cerebrosides to PL increased sharply in RW fruit. The ratio of 18:2 to 18:3 declined with chilling and with rewarming in all acyl lipids, but total unsaturation increased only in GL. These results indicate that most membrane damage occurs after rewarming and that the chloroplasts are especially chilling sensitive.

479

HIGH-PRESSURE GAS ATMOSPHERES AND ANESTHETICS ALTER THE CHILLING SENSITIVITY OF PLANTS

Mikal E. Saltveit, Jr., Mann Laboratory, Department of Vegetable Crops, University of California, Davis, CA 95616-8631

Changes in membrane fluidity at low, non-freezing temperatures are thought to be involved in chilling injury - a physiological disorder of many economically important plants, e.g. banana, cucumber, maize, rice, and tomato. Atmospheres of 12 MPa He or $N_2$ increased the rate of ion leakage from excised cucumber cotyledon discs, cucumber hypocotyl segments and tomato pericarp discs and also increased the threshold temperature at which chilling occurred by 2° to 6°C. Exposure to vapors of the mammalian anesthetics halothane and methoxyflurane reduced chilling injury in the same tissues. The relative effectiveness of the two anesthetics in reducing chilling injury was similar to their relative effectiveness in inducing anesthesia in animals and their relative lipid solubilities. The response of the tissues to halothane and methoxyflurane, which are known to increase membrane fluidity, and to high pressures, which are known to reduce membrane fluidity, are consistent with the hypothesis that a cold-induced phase transition of membranes could be responsible for chilling injury.

480

CHILLING INJURY ON GRAPEFRUIT IS RELATED TO GAS PERMEABILITY OF THE PEEL

Roy E. McDonald* and T. Gregory McCollum, USDA, ARS, U.S. Horticultural Research Laboratory, 2120 Camden Road, Orlando, FL 32803

Differences in chilling injury (CI) susceptibility of 'Marsh' grapefruit (Citrus paradisi Macf.) from interior and exterior tree canopy positions were used to determine the effects of temperature conditioning (7 days at 21C), application of squalene (10% in hexane), and high oxygen (42%) atmospheres on CI development during low temperature storage. Chilling injury was significantly lower on interior tree canopy, temperature conditioned, squalene treated, and fruit stored in ambient oxygen atmospheres compared



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combination of direct seeding and transplanting for establishment and harvest using the cut harvest method (whole plant, single harvest) is optimal in early season with direct seeding with shucking (leafs stripped, multiple harvests) appropriate later. Harvest efficiency is higher and cost is lower with the cut harvest method, but shucked yields are higher and shucked product is preferred by buyers. Additional quality and economic analyses indicate that product should be hydrocooled and packed with crushed ice.

725 (PS 6)

GROWING GLOBE ARTICHOKES AS AN ANNUAL IN VIRGINIA

Gregory E. Welbaum, Department of Horticulture, Virginia Polytechnic Institute & State University, Blacksburg, VA 24061-0327.

The globe artichoke (*Cynara scolymus* L.) is a herbaceous, perennial dicot grown for its immature flower bud. Globe artichokes are usually propagated vegetatively from root divisions or offshoots, because plants grown from seed lack uniformity. Furthermore, only a small percentage of plants grown from seed flower during the first season without vernalization. The globe artichoke is not winter hardy and cannot be grown in areas where temperatures are < −10°C without protection. The cultivar Imperial Star was developed in California to produce uniform plants from seed and a high percentage of buds the first year. In this study, Imperial Star (IS) and Green Globe (GG) were evaluated for their ability to produce a crop during the first season from seed without vernalization in Virginia. Eight-week-old transplants were set in the field on 14 May 1991. The harvest period began on 12 August for both cultivars and ended on 28 September and 8 November for GG and IS, respectively. Eighty-one percent of the IS produced buds compared to 25% for GG. The average bud yield per plant was 12 for IS and 9 for GG. Ten and 9% of the buds were rated as off-type for IS and GG, respectively. The average bud weight was 77 and 80 grams for IS and GG, respectively. Only 54 and 49% of the IS and GG buds, respectively, exceeded the marketable weight of 75 grams. The percent marketable yield for IS was 46% and 42% for GG. The estimated marketable yield per hectare was 54,600 and 4,800 buds for IS and GG, respectively. Imperial Star is a significant improvement over GG plants grown from seed in short season areas.

726 (PS 7)

SIMULATION OF HOURLY TEMPERATURES AND ESTIMATION OF CHILL UNITS.

Raymundo Rojas-Martinez*, Schuyler D. Seeley, and Donald Jensen, Plants, Soils and Biometeorology, Utah State University, Logan, UT 84322

A model [HeatSine-Exponential (HSE)] for the course of diurnal temperatures was validated with forty-three years of hourly temperatures from the Salt Lake City (Utah) airport . Daily parameters of the HSE model were determined by non-linear regression analysis. The HSE was compared to linear and other sine-exponential formulations. The HSE model had the highest average coefficient of determination ($r^2$ = 0.89) and the lowest average root mean square error (0.92C). All the models under study were tested for the estimation of chill units and compared against chill accumulations computed directly from hourly temperatures. The HSE and sine-exponential models were simplified through systematic variation of the model parameters. Deviations from the hourly temperature results were analyzed using relative error (RE). The average RE for the HSE model was 3.3% [standard deviation (s) = 3.0]. The best linear method estimated chill units with an average RE of 6.1% (s = 4.3).

727 (PS 7)

**MATHEMATICAL MODELLING OF TREE CROP ORCHARD DESIGN: INTERTREE SHADING DURING CRITICAL SEASONAL GROWTH AND DEVELOPMENTAL WINDOWS AND ITS IMPLICATIONS ON OPTIMAL SPACING**

Jeffrey W. Burcaw*, Bruce W. Wood, Michael W. Poole, and Mark T. Burnette; USDA/ARS Southeastern Fruit and Tree Nut Research Laboratory, Byron, GA 31008

The authors have developed a computer 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.

Tree shape is modelled as an ellipsoid bisected about the semi-minor axis, with ellipsoid dimensions and eccentricity altered to reflect growth stages of the trees. Intertree shading is measured as the surface area of the projected shadow on the ellipsoid. Variables include crop, light extinction, ellipsoid dimensions, intertree spacing, orchard geometry, time and day of the year, and geographical coordinates. Simulations compared the sunlight-related attributes of a variety of orchard geometries for different growth phases of the trees during different parts of the year for several global locations. Results indicate extensive variability of intertree shading to be a function of latitude, regardless of other variables.

728 (PS 7)

ROOT RESTRICTION AND PHOTOSYNTHETIC RESPONSE IN A PEACH ROOTSTOCK

Giannina Vizzotto, Orietta Lain and Guglielmo Costa* Produzione Vegetale e Tecnologie Agrarie Dept., University of Udine, 33100 Udine, Italy

Experiments on root restriction effect were carried out on micropropagated peach rootstock (GF677) plants grown in pots with different volume (1350 and 270 ml).

Root restriction reduced plant growth expressed as shoot length, FW and DW accumulation and leaf area. Application of a triazole (BAS 111, GA biosynthesis inhibitor) or TIBA (inhibitor of auxin polar transport) also reduced plant growth as compared to root restriction.

Pn measured on expanded leaves developed during the time-course experiment showed to be affected by root restriction. In fact the assimilation rate exhibited by plants grown in 270 ml volume pots remained at lower level at least at the lower light intensities. TIBA treatment dramatically reduced the assimilation rate at all the light intensities tested, while BAS111 did not induced evident differences as compared to the control plants. The stomata density per leaf doubled in the plants grown in 1350 ml pots as compared to that of plants in the 270 ml pots.

729 (PS 7)

MORPHOLOGICAL EFFECTS OF VARIABLE LEVELS OF ROOT RESTRICTION ON 'LORING' AND 'REDHAVEN' PEACHES IN DIFFERENT ENVIRONMENTS

Leonardo R. Alvarez* and Caula Beyl, Department of Plant and Soil Science, Alabama A&M University, Normal, AL 35762.

A greenhouse and parallel field study were established to evaluate different levels of root restriction and their influence on shoot development. One year old 'Loring' and 'Redhaven' peach (*Prunus persica* L. Batsch) were grown for 7 months in containers with volumes ranging from 1.93 to 19.2 L using a mixture of kitty litter, sand (1:1v). Plants were irrigated daily and fertilized weekly. Plants grown in small containers (highly restricted 1.93-3.85 liters) exhibited less leaf expansion and caliper development. Number of primary shoots, total combined length of secondary shoots, and total length of all shoots were reduced. Shoot/root ratio was not altered by the container volumes suggesting a coordination of root and shoot growth modulated by the container volume. The same trends were observed in both field and greenhouse. Root fresh weight was reduced by the highly restricted versus the less restricted treatment (15.4-19.25L) the same extent irrespective of cultivar and location with values ranging from 33.1-38.6%.

730 (PS 7)

TOLERANCE OF PEACH ROOTSTOCKS TO IRON CHLOROSIS

Wade J. Sperry* and David R. Walker, Department of Plants, Soils and Biometeorology, Utah State University, Logan, UT 84322

Bailey, Lovell and Halford peach rootstocks were evaluated to determine their tolerance to iron chlorosis. Two year old trees budded with Redhaven scions were used. Experiments were carried out in a greenhouse with trees grown in nutrient solutions and soil. Soil was obtained from an orchard with a history of severe iron chlorosis problems. Nutrient solutions were treated with bicarbonate, and pH was maintained at approximately 8.3 to induce iron chlorosis symptoms. Mean chlorophyll content of leaves from Redhaven on Halford was 42 mg/m$^2$ which was significantly higher than Redhaven on Bailey (30.3 mg/m$^2$) and Redhaven on Lovell (28.4 mg/m$^2$). Photosynthetic rates of leaves from Redhaven on Halford were significantly higher (16.6 μm/m$^2$/sec) than those on Bailey (7.3 μm/m$^2$/sec) and on Lovell (2.1 μm/m$^2$/sec). Shoot growth was measured weekly. Redhaven shoots on Halford had significantly more shoot growth (80 cm) from the beginning of the experiments than on Bailey (23 cm) and on Lovell (19 cm). Results from these experiments show that Halford rootstock with a Redhaven scion is more tolerant to iron chlorosis than Bailey and Lovell rootstocks with Redhaven scions.

731 (PS 7)

YIELD COMPONENTS IN SPUR VS. NON-SPUR STRAINS OF 'DELICIOUS' APPLE ON TWO ROOTSTOCKS

F.G. Dennis, Jr.,* J. Masabni and D.O. Ketchie. Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325, and Tree Fruit Research Center, Washington State University, Wenatchee, WA 98801.

Yield components of spur and non-spur strains of 'Delicious' apple on 2 rootstocks were compared over 4 years (5th through 8th leaf). Yield per unit trunk cross-sectional area was higher in spurs than in non-spurs with but few exceptions. Differences in fruit set, rather than in flower density or fruit size, were largely responsible for this difference in yield. Yields were higher on EMLA 7 than EMLA 111 rootstock, partially because of earlier bearing. When cropload was factored out, fruit size was slightly greater on EMLA 7 than on EMLA 111.



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718 (PS 6)
EVALUATION OF HARVEST SCENARIOS FOR COWPEA (*Vigna unguiculata* L. Walp), A CANDIDATE SPECIES FOR CONTROLLED ECOLOGICAL LIFE-SUPPORT SYSTEMS
Tracy A. Ohler* and Cary A. Mitchell, NASA Specialized Center of Research and Training in Bioregenerative Life Support, Purdue University, West Lafayette, IN 47907-1165

Physiological characteristics of cowpea suggest it as a candidate species for CELSS. Improving productivity will be essential for CELSS. The leaves of cowpea provide an added source of edible biomass and may extend harvest index (HI=edible/total biomass). A greenhouse study evaluated the interaction of photoperiod and cultivar with 3 harvest scenarios: 1) seed only, 2) seed and leaves (mixed), and 3) leaves only. Overall, seed-only HI was 25% less than leaf-only HI. For IT84S-2246, a short-day cultivar for flowering, both mixed and seed only HI dropped 20% as photoperiod increased from 8 to 24 hours. While edible yield rate remained constant, shoot dry weight increased as photoperiod increased for both harvest scenarios, thus decreasing HI. For the same reason, the leaf-only HI of S-2246 increased as photoperiod increased. For IT82D-889, a day-neutral cultivar for flowering, HI remained constant regardless of photoperiod. Leaf-only HI was 65%, whereas seed and mixed HIs were 40 and 45% respectively. For all harvest scenarios, D-889 produced 25 grams less edible biomass per plant than that of S-2246. Due to the interaction of harvest scenario and cultivar, cultivar selection must be based on yield performance in each type of harvest scenario. Further investigations will answer the extent of sacrificing seed yield for leaf harvest. NASA Grant NAGW-2329.

719 (PS 6)
BRUSHING TREATMENTS FOR HEIGHT CONTROL OF VEGETABLE AND ORNAMENTAL TRANSPLANTS
Michael A. Schnelle* and B. Dean McCraw, Department of Horticulture and Landscape Architecture, Oklahoma State University, Stillwater, OK 74078-0511

Height control for vegetable transplants has become challenging with the loss of the industry standard growth regulator, daminozide (B-Nine). Although chemical growth regulators remain legal for use in nonedible crops, their margins of safety, costs and looming reregistration uncertain ties, justify the investigation of nonchemical height control methods. Various cultivars of Lycopersicon esculentum and Capsicum annuum, were subjected to daily brushing treatments for at least four weeks. Various ornamental cultivars, which currently can be kept chemically compact, were also subjected to the same treatments. The experimental apparatus height and weight differences among test plants and the method's economic feasibility on a commercial basis will be discussed.

720 (PS 6)
TILLAGE, COVER,AND ALLELOPATHIC EFFECTS ON BROCCOLI.
W.T. Kelley*, University of Georgia, Department of Horticulture, Tifton, GA 31793 and D.L. Coffey, University of Tennessee, Department of Plant & Soil Science, Knoxville, TN 37901-1071.

'Packman' hybrid broccoli was grown under three tillage systems at three locations in 1989 and 1990 to study the feasibility of no-till production. Tillage systems consisted of 1) conventional tillage with no winter cover, 2) conventional tillage with wheat winter cover, and 3) no-till transplanted directly into paraquat-killed wheat cover. Locations were at Knoxville, Greeneville and Crossville, TN. Yield, value and marketability of broccoli were significantly reduced in no-till vs conventional tillage. The possibility that small grain cover crops have a deleterious effect on broccoli growth was then investigated. Broccoli was grown in greenhouse pots with solutions of ferulic, syringic, p-coumaric, p-hydroxybenzoic and vanillic acids at 1, 10, 100 and 1000 $\mu$M concentrations and compared to controls which received only water. Shoot dry weight and plant height were both reduced with increasing acid concentrations. Soil samples were taken from field plots in 1990 and analyzed for levels of these acids using HPLC. Soils with higher levels of mulch had higher levels of ferulic and p-coumaric acid, but similar levels of the other acids. Allelopathic effects of the cover crop is a potential cause of reduced broccoli yields under no-till conditions.

721 (PS 6)
EFFECT OF SHADING ON TOMATO
V. M. Russo, United States Department of Agriculture, Agricultural Research Service, South Central Agricultural Research Laboratory, P. O. Box 159, Lane, Oklahoma 74555

High day and/or night temperatures interfere with fruit set of tomato (Lycopersicon esculentum Mill.). Shading may protect flowers and increase fruit set and yield. The cvs. 'Flash' and 'Sunny', which do not set fruit under night temperatures above 21.1°C were planted in mid-May, mid-June, and mid-July in 1991 and 1992 into a Bernow fine-loamy, siliceous, thermic Glossic Paleudalf soil at Lane, Oklahoma. Sixty-percent shade cloth was attached to T-shaped supports over one-half of the plots three weeks after planting. High-low temperature thermometers were suspended on supports in beds with and without shade. Shading reduced high and low temperatures by 2.5 and 1° C below ambient. Earlier planting improved yield, but cultivar or shading did not. Shading increased plant dry weight in 1992. Dry weight was positively correlated (p=0.01) with yield. Shading did not increase yield. Other levels of shading, removal of shade for a portion of the day, or erecting shading at transplanting may affect yield differently.

722 (PS 6)
INFLUENCE OF NITROGEN AND PLANT SPACING ON SPORT PEPPERS
Carl E. Motsenbocker*, William A. Mulkey, James E. Boudreaux, and J. Blair Buckley. Dept. of Horticulture, Chase Research Station, L.S.U. Cooperative Extension, and Calhoun Research Station, L.S.U. Agricultural Center, Baton Rouge, LA 70803.

Field studies were conducted in 1992 with 'Mississippi Sport' pepper. Plants were established by direct seeding at 8 cm or transplanting at 8, 15, 23 and 30 cm in-row plant spacing. All in-row plant spacings received one of five nitrogen applications (0, 55, 110, 165, 220 kg pe hectare). Plant parameters, fruit quality and yield were monitored. A modified commercial snap-bean harvester was evaluated for harvest. Closer plant spacings resulted in greater red and combined red and green grade yields. Nitrogen rate did not influence yield or stem diameter and height. The use of the modified mechanical snap-bean harvester appears to be a feasible technique to harvest sport pepper.

723 (PS 6)
RYEGRASS AND CLOVER AS LIVING MULCHES FOR SWEET CORN ON SANDY SOIL
Astrid C. Newenhouse* and Helen C. Harrison, Dept. of Horticulture, University of Wisconsin-Madison, Madison, WI 53706.

Two living mulches were studied for their effect on weed control and nitrogen cycling in sweet corn grown on sandy soil under sprinkler irrigation. Plots with either annual ryegrass (*Lolium perenne*) or dwarf white clover (*Trifolium repens*) planted between sweet corn rows were compared to plots kept weed free by cultivation or herbicides. Each sweet corn plot (18.3m x 3.7m) was split into two subplots according to level of applied nitrogen. One subplot received 112 kg N/ha (100 #/A) and the other 224 kg N/ha (200#/A). Nitrate and ammonium levels were measured in soil samples and nitrogen levels were measured in plant tissue samples. Measurements such as corn height were taken, as well as percent mulch cover, plant tissue fresh weight and dry weight, total corn yield and marketable yield, and weed counts. Applied nitrogen leached through the soil profile more rapidly than expected (within 2 weeks) and sweet corn growth and yield were poor in all the low level nitrogen plots. Even at the high nitrogen level, sweet corn yield was limited by mulch growth. The weed control benefits of this living mulch system could potentially be realized if mulch competition were limited, especially during early growth stages of the corn.

724 (PS 6)
A SYSTEMS APPROACH TO PRODUCTION AND MARKETING FRESH-MARKET COLLARDS IN THE MIDSOUTH
Tina Gray Teague* and Paul W. Teague, Arkansas State University, State University, AR 72467

Results from research conducted in commercial fields, the ASU research farm, and commercial packing sheds were used to construct a production and marketing system for spring fresh market collards. The system was based on results from studies conducted in 1989 through 1993 which included date of planting trials, transplant population density studies, crop establishment comparisons, harvest method analyses, economic analyses of infrastructure requirements, quality comparisons with different post harvest handling methods, and buyer preference surveys. A system analysis was imposed to create a production/marketing program to provide 1000 boxes (9.1kg) of collards/wk for the Arkansas spring season, mid-April through June. Product would supply local markets and terminal markets in midwestern (Chicago and Detroit) and southwestern (Dallas and Houston) cities where Midsouth greens producers have comparative transportation advantage over other U.S. production regions. Results indicate that a

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739 (PS 7)

EFFECTS OF FIVE DWARFING ROOTSTOCKS ON GROWTH, PRECOCITY AND LEAF MINERAL COMPOSITION OF APPLE CULTIVARS

Shakeel A. Khan* and Frank B. Matta, Department of Horticulture Mississippi State University, Mississippi State, MS 39762

The influence of MM-111, MM-106, M-7A, M-26, and Mark rootstocks on growth, precocity and leaf mineral composition of various apple cultivars (Royal Gala, Ultra Mac, Empire, Jon-A-Red, Ultra Gold, Blushing Golden and Braeburn) were evaluated for two years in Mississippi. The smallest trees were observed in case of 'Ultra Mac' and 'Blushing Golden' on M-7A rootstock in 1991. Mark in the second year for all combinations produced the smallest trunk cross-sectional area (TCSA) as compared to all other scion stock combinations. All rootstocks induced precocity in 'Royal Gala', 'Jon-A-Red', 'Ultra Gold', 'Braeburn' and 'Blushing Golden'. 'Ultra Mac' and 'Empire' remained vegetative with the only exception of 'Empire' on Mark which showed precociousness. Rootstocks had a significant effect on nutrient contents of N, in leaves of 'Ultra Mac', 'Empire', 'Ultra Gold' and 'Blushing Golden'; on Mg in leaves of 'Royal Gala', 'Jon-A-Red', 'Ultra Gold' and 'Blushing Golden'; on Cu in leaves of 'Empire', 'Ultra Gold' and 'Blushing Golden'; on Mn in leaves of 'Empire' and 'Ultra Gold'; on Ca in leaves of 'Jon-A-Red' and 'Ultra Mac'; on K in leaves of 'Braeburn'; on Zn in leaves of 'Ultra Mac'; and on Fe in leaves of 'Empire'.

740 (PS 7)

SCION/ROOTSTOCK EFFECTS ON TREE SIZE, CUMULATIVE YIELD AND YIELD EFFICIENCY OF 'GRANNY SMITH' APPLE AND ITS SPORTS, 'GRANSPUR' AND 'GREENSPUR'

Fenton E Larsen and Stewart S. Higgins, Department of Horticulture and Landscape Architecture, Washington State University, Pullman, WA 99164-6414

Cumulative yield, tree size (trunk cross-sectional area) and cumulative yield efficiency were evaluated after 6 years of production on trees of 'Granny Smith', 'Granspur', or 'Greenspur' on seedling (sdlg), MM 111, MM 106, M 26 or M 7a rootstocks. There were no interactions between scion and rootstock for any of the measured response variables. After 6 years, 'Granny Smith' produced more fruit than either 'Granspur' or 'Greenspur'. Trees on MM 106 produced the highest cumulative yield per tree while trees on M 26 produced the least. Trees on M 7a, MM 111 and sdlg roots were intermediate in production. Trunk cross-sectional area of 'Granny Smith' was larger than either 'Granspur' or 'Greenspur'. Trees on sdlg roots were larger than all others, and trees on M 26 were smaller. 'Granny Smith' and 'Greenspur' had higher yield efficiencies than 'Granspur'. Trees on MM 106 and M 26 had higher yield efficiencies than on other roots, and trees on sdlg had lower yield efficiencies.

741 (PS 7)

EFFECTS OF SEVERAL GROWTH-CONTROLLING TECHNIQUES ON APPLE TREES

Wesley R. Autio* and Duane W. Greene, Department of Plant & Soil Sciences, University of Massachusetts, Amherst, MA 01003

In 1991, 'Gardiner Delicious'/MM.106 trees and in 1992, 'McIntosh'/MM.106 trees were root pruned (1 m from the trunk, 30 cm deep), trunk scored (single, circle, 40 cm from the soil), trunk ringed (single, circle, 1 mm wide, 40 cm from the soil), ethrel treated (500 ppm), or not treated. Treatments were applied when terminal growth was 12-15 cm. Trunk growth was less for ringed and scored trees than the controls. Ringing and scoring advanced ripening compared to controls for 'Delicious' in 1991, and ethrel was the only treatment that resulted in advanced ripening of 'McIntosh' in 1992. Treatments had no effect on fruit size or flesh firmness for 'Delicious' in 1991; however, in 1992, fruit size and flesh firmness of 'McIntosh' fruit were reduced by ethrel. In both years, trees that were treated with ethrel in May had the most rapid abscision rate during the harvest season. Root pruning was conducted in two commercial orchards in 1991 and 1992. Compared to controls, root pruning in 1991 reduced fruit abscision from 'Cortland'/M.7A and 'McIntosh'/MM.106 trees both in 1991 and 1992. Root pruning in 1992 did not affect abscision alone or in combination with root pruning in 1991.

742 (PS 7)

THIRD YEAR YIELD OF A HIGH DENSITY APPLE ORCHARD AS INFLUENCED BY TRAINING SYSTEM, IRRIGATION AND SOIL TREATMENT IN A REPLANTED, OLD ORCHARD SITE.

C.R. Unrath* Dept. of Horticultural Science, North Carolina State University, Mtn. Hort. Crops Res. and Ext. Ctr., 2016 Fanning Bridge Road, Fletcher, NC 28732

In April, 1990, 'Smoothee Golden Delicious' trees on Mark rootstock were planted in a high density orchard, 1.5m X 3.0m = 2152 trees/ha (5'X10' = 871 t/a), in an old apple orchard site. Soil treatments of preplant fumigation (F) with methyl-bromide, fumigation plus postplant Ridomil (F+R) in spring and fall and monoammonium phosphate (MAP) incorporated into the tree hole were included to evaluate their influence on tree vigor. In 1992, slender spindle (SS) training increased third season yield by +79% over HYTEC training; supplemental summer irrigation (Irr.) +4%, F +6%, F+R +20 and MAP -17% over no soil treatment.

The HYTEC trained trees with no irrigation or soil treatment might roughly compare to a "check" or a typical grower technique, this treatment yielded 13,364 kg/ha (284 bu/a). Looking at some other selected treatments; SS w/no irr. or soil trt. increased yield by +27% over the HYTEC (check) trt.; SS+F = +63%, SS+Irr. = +107%, SS+Irr.+F = +112% and SS+Irr.+ F+R = +169% or 35,902 kg/ha (763 bu/a).

743 (PS 7)

NY 151 APPLE SELECTION - SO HARD ITS FIRMNESS SHOULD BE MEASURED WITH AN 8 MM PENETROMETER.

George M. Greene II, Dept. of Horticulture, Penn. State Univ., Fruit Research Laboratory, PO Box 309, Biglerville, PA 17307-0309

The NY 151 apple selection, a cross of Kuppens Red Spy X Yorking, was made by Roger Way of Cornell University at the NYSAES in Geneva, NY. Due to several orchard weaknesses it was deleted from the NY program but it has performed well in the hot humid mid-Atlantic area. At harvest fruit quality measurements were made over the period 280 to 310 Julian days with the following results: soluble solids rose from 12% to 14.5%; flesh color changed from greenish-white to white and taste changed from tart-balanced to balanced. Fruit firmness often exceeded the 126 newton (N) upper limit of the McCormick tester using an 11 mm tip. Fruit from the 1991 harvest tested about 84 N coming out of cold storage in Feb. but were about 106 N coming out of CA storage in July. In 1992, apples harvested on Oct. 13 and Nov. 4 measured 133 N 75% and 32% of the time respectively, which is the upper limit of the Magness-Taylor tester. In order to compare the 8 and 11 mm tips 150 apples were tested with each tip. Values for the 8 mm tip ranged from 30 - 87 N and from 52 - 133 N for the 11 mm tip. Eleven mm firmness values can be predicted from 8 mm values by the equation $y = 3.17 + 1.62x$ (R squared =.758). Although recommended for pears the 8 mm tip should be used for measuring the at harvest firmness of NY 151 apples.

744 (PS 7)

MECHANICAL PEACH HARVESTING LIMITED POTENTIAL

D. Michael Glenn*, Donald L. Peterson and Stephen S. Miller, USDA, ARS, Appalachian Fruit Research Station, 45 Wiltshire Rd., Kearneysville, WV 25430

The purpose of this six year study was to re-evaluate the potential of mechanical peach harvesting in a mechanized irrigated peach production system. 'Redhaven', 'Harvester' and 'Autumnglo' peach cultivars were trained to a free-standing "Y" form and received: a) full season irrigation; b) irrigation during the ripening period; or c) no irrigation. Trees were 2.5 m within the row and individual plots contained 10 trees with 4 replications in a split plot design. All three cultivars were mechanically harvested using the USDA inertial shaker. In addition, the cultivar 'Autumnglo' was hand harvested as a control. The percentage of mechanically harvested firm ripe fruit ranged from 64 to 95%. Fruit damage ranged from 5 to 36%. In all years, non-irrigated trees tended to have the highest harvest percentage suggesting that irrigation may widen the maturity range of peach. Fruit damage occurred due to roughly cut shoot stubs and when debris in the canopy became lodged in the harvester's conveyor system. Accelerated tree death from mechanical harvesting was noted in 'Autumnglo'. We concluded that the limitations to mechanical peach harvesting outlined in the 1970's have not been overcome.

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745 (PS 7)

MECHANCIAL PEACH THINNING

D. Michael Glenn*[1], Donald L. Peterson[1], Daniela Giovannini[2] and Miklos Faust[3], USDA, ARS, Appalachian Fruit Research Station, 45 Wiltshire Rd., Kearneysville, WV 25430[1]; Istituto Sperimentale Per La FruttiColtura, di Roma, Sezione di Forlit Piazzale Della Vittoria, 15, Forli, Italy 47100[2]; USDA, ARS, Fruit Laboratory, Room 119, Building 004, Beltsville, MD 20705[3]

The purpose of these studies was to compare two mechanical means of thinning with hand thinning peaches 40-60 days after full bloom. A spiked-drum canopy shaker and a trunk impacter shaker were used to thin 'Loring' peach trained to 'Y' shape. Initial studies demonstrated that the spiked-drum shaker removed more fruit from horizontal than vertical branches. The spiked-drum shaker did not preferentially remove larger or smaller fruit. The yield of large fruit was not significantly different for hand or mechanically thinned trees when fruit was thinned 40-60 days after full bloom.

746 (PS 7)

**SCION AFFECTS INCIDENCE OF PEACH TREE SHORT LIFE**

**Thomas G. Beckman*, William R. Okie and Andrew P. Nyczepir, U.S. Dept. of Agriculture, Agricultural Research Service, Southeastern Fruit and Tree Nut Research Lab., P.O. Box 87, Byron, GA 31008 USA**

**Preliminary results of a field trial of 49 different scion varieties grafted onto Nemaguard plus 'Redhaven'/Lovell suggest that scion influence on incidence of peach tree short life (PTSL) may be comparable to that of rootstock. After 6 growing seasons survival of the various scion treatments ranged from 5 to 85%. Correlation analyses indicated that those scion varieties exhibiting either early bloom or late defoliation survived better and that those varieties exhibiting both characteristics survived the best. Results indicate that final testing of rootstock candidates for PTSL tolerance must be done with grafted materials and that it may be possible to recommend the planting of certain scion varieties on PTSL sites as well as particular rootstocks for maximum longevity.**

747 (PS 8)

CHANGES IN MONO-, DI-, AND POLYAMINE LEVELS IN *CITRUS* FRUIT TISSUES DURING FRUIT ENLARGEMENT

Mohamed El-Otmani*, Charles W. Coggins, Jr., and Carol J. Lovatt, Department of Botany and Plant Sciences, University of California, Riverside, CA 92521-0124

Mono-, di- and polyamines are known to influence growth and development processes in plant organs. Because of the complexity of citrus fruit, we investigated the relative distribution and changes occurring in endogenous levels of the free form of these compounds in the three major fruit tissues (i.e., flavedo, albedo, and juice vesicles) of the 'Washington' navel orange (*Citrus sinensis* L. Osbeck) during the period of exponential growth (i.e., from 2 to 8 cm in diameter). In young fruit (2 to 4 cm), putrescine levels were highest in juice vesicles > flavedo > albedo, decreasing during growth to a minimum when fruit were 4 to 5 cm in diameter. Fully grown fruit undergoing maturation exhibited a significant increase in putrescine with albedo > flavedo > juice vesicles. Spermidine followed similar trends in albedo and flavedo, but decreased in the endocarp. Spermine levels steadily declined in all tissues with fruit growth to barely detectable amounts when fruit reached full size. Phenylethylamine was absent in the flavedo, whereas tyramine and dopamine were present in significant amounts, especially during early fruit growth. The significance of these changes to fruit growth and development will be discussed.

748 (PS 8)

CITRUS COLD PROTECTION WITH SPRINKLERS

J. David Martsolf*, Horticultural Sciences Dept., IFAS, University of Florida, Gainesville, FL 32611

Observing plant damage following a frost or freeze is perhaps the oldest and likely one of the most frequently used methods by horticulturists to assess relative merits of protection methods. To facilitate that method, a citrus orchard of 66 Ambersweet on Sour Orange, 198 Orlando Tangelo and 197 Robinson tangerine, the latter two varieties on Carrizo Citrange, was planted in early April of 1990, on the main campus of UF. The variety rows run the N-S with trees separated by 4.6m. The 11 different sprinkling treatments run E-W with separations of 6.1m. When 461 sprinklers are utilized the well delivers rates up to 60 l/hr/nozzle. A visitor can walk a N_S middle and view each treatment on a particular variety in series. During the winter of 90-91, half the trees had conventional under-tree sprinklers while the other half had various types of in-tree sprinklers. Following an advective freeze, Feb. 15-17, 32% of the trees with in-tree sprinklers had broken limbs compared with 4% of those with under-tree sprinklers. But estimates of canopy damage indicated less difference between the treatments, and measurements of tree height before and after freezes were so variable that significant differences were not apparent. Observations following mild freezes in 91-92 indicated high variability in the effects of a particular method on individual trees. Problems in the development of a tree imaging technique using a still image video camera [Cannon RC-250] and the use of such observations in refining mechanismal models are highlighted.

749 (PS 8)

HORTICULTURAL SOLUTION TO PROTECTING YOUNG CITRUS TREES FROM SUBTERRANEAN TERMITE DAMAGE

Robert E. Rouse* and Philip A. Stansly, Southwest Florida Research and Education Center, University of Florida, IFAS, P.O. Drawer 5127, Immokalee, FL 33934

The eastern subterranean termite, (*Reticulitermes flavipes* (Koller) has caused extensive losses in localized areas of young citrus in southwest Florida by girdling trees between the crown roots and planted soil line. Applications of insecticides provided only short term deterrence lasting only a few months, and granular formulations in general have been most effective. Since termites will not venture far from the protection of moist soil and their primary area of attack has been found to be the trunk cambium below the soil line and not the roots, shallow planting and/or removal of soil have been found to be effective controls. Removing the soil around the affected trees to expose the tops of the crown roots has almost always resulted in arresting termite attack and allowing the tree to recover. Planting trees shallow does not slow tree growth.

750 (PS 8)

AMMONIA AND/OR ITS METABOLITES INFLUENCE FLOWERING, FRUIT SET, AND YIELD OF THE 'WASHINGTON' NAVEL ORANGE

Anwar G. Ali, Yusheng Zheng, Oded Sagee, Calixto Protacio, and Carol J. Lovatt, Department of Botany and Plant Sciences, University of California, Riverside, CA 92521-0124

A cause and effect relationship between tree ammonia status and floral intensity was established for *Citrus sinensis* L. cv. Washington navel orange. Artificially raising tree ammonia content by foliar application of low-biuret urea during or at the end of a minimal stress treatment increased leaf ammonia content and both the number of floral shoots and flowers per shoot, but did not increase vegetative shoot production. Apical flowers initiated in response to stress exhibited maximum tissue concentrations of ammonia and putrescine and activity of the *de novo* arginine biosynthetic pathway one week after the end of the stress treatment. All three criteria decreased in parallel as flowers developed through petal fall. Foliar-applications of low-biuret urea during early bloom increased ovary putrescine content and fruit set. Winter foliar applications of low-biuret urea to commercially-producing, nitrogen-sufficient 'Washington' navel orange trees just prior to or during flower initiation increased yield by approximately one packing carton (17 kg) per tree in three successive years without a reduction in fruit size. Winter application of low-biuret urea was cost effective.

751 (PS 8)

FLOWERING PEAK MODELS OF MACADAMIA (*MACADAMIA INTEGRIFOLIA*)

San-Gwang Hwang, Kent D. Kobayashi*, and Mike A. Nagao
Department of Horticulture, University of Hawaii at Manoa, Honolulu, HI 96822 USA

Statistical models were developed to predict the days from the starting date of the flowering season to the first peak of flowering of macadamia. The macadamia (*Macadamia integrifolia* Maiden and Betche ) cultivar Ikaika was studied at two locations on the island of Hawaii. At location 1, TGDD and TSOLAR were the factors included in the model, where TGDD is the total growing degree days accumulated during the 18 weeks after the ending date to the next starting date of the flowering season. TSOLAR is the total solar radiation accumulated during the 18 weeks after the ending date to the next starting date of the flowering season. The model predicted the first flowering peak one day before it occurred in the field. At location 2, MINT and TGDD were the factors included in the model, where MINT is the average daily minimum temperature during the 18 weeks after the ending date to the next starting date of the flowering season. The model predicted the first flowering peak on the day it occurred in the field. These models could be used to help predict the first flowering peak so that bees could be brought in to increase cross-pollination and subsequent yields.

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752 (PS 8)

A HYPERTEXT INFORMATION SYSTEM FOR CROP LOGGING OF MACADAMIA (*MACADAMIA INTEGRIFOLIA*)

Kent D. Kobayashi*, Howard H. Hirae[1], and H.C. Bittenbender
Department of Horticulture, University of Hawaii at Manoa, Honolulu, HI 96822 USA. [1]Cooperative Extension Service, University of Hawaii, Hilo, HI 96720 USA

Crop logging is a useful tool to keep track of the nutrient status of fruit trees. Crop logging can help extension personnel and farmers diagnose possible nutrient deficiency or toxicity problems and schedule fertilizer practices. A hypertext information system called "Tissue Analysis" was developed for crop logging of macadamia (*Macadamia integrifolia* Maiden and Betch) trees. The system runs on an Apple® Macintosh® computer using the software HyperCard® 2.0. It allows the user to keep track of the tissue analyses records of different farmers and their orchards and serves as a "front end" to link to the user's spreadsheet worksheets and charts of different nutrients. The user can create and maintain a list of farmers whereby a separate file is created for each farmer that then allows the user to create and maintain a list of the farmer's orchards. For each orchard, the user can name buttons according to different nutrients and set up linkages to spreadsheet worksheets and charts to view tissue analyses records. This information system can aid extension agents and farmers in monitoring the nutrient status of different orchards, diagnose possible nutritional problems, and schedule fertilizer applications.

753 (PS 8)

SUNLIGHT ATTENUATION AND NUTRITIONAL REQUIREMENTS FOR COCOA PLANTATIONS

Victor H. Delgado-Nuñez and J. Angel Saavedra[1]* CE Huimanguillo, INIFAP Apdo. postal 19, Huimanguillo, Tab. 86400 [1]CE Cotaxtla, INIFAP Apdo. postal 429, Veracruz, Ver. 91700, México

Two levels of natural sunlight attenuation and three levels of fertilizer were evaluated on five-year-old cocoa trees growing under field conditions. Sunlight effect was evaluated by comparing two densities of shade trees, *Gliricidia sepium*: 4x4 m and 8x4 m, allowing aproximately 25% and 50% of full sunlight (2000 $\mu$mol $m^{-2}$ $s^{-1}$), respectively. The amount of soil-applied fertilizer was 0 (control), 700, and 1000 g $tree^{-1}$ $year^{-1}$ 17-17-17 (N-P-K) applied twice a year. Treatments were replicated 3 times in a split-plot design. Shade density of 8x4 m yielded the best dry cocoa bean production per ha. Production increased proportionally with the amount of fertilizer. We conclude that as the amount of light reaching tree canopy increases, the need for fertilizer also increases, and consequently yields improve. However, cocoa growers have to manage this characteristic carefully because tree life is diminished under more sunlight.

754 (PS 8)

BREEDING SITES AND INSECTICIDES EVALUATION TO PROTECT AND INCREASE POPULATION OF COCOA POLLINATORS

José I. López-Arroyo, J. Angel Saavedra[1]* CE Huimanguillo, INIFAP Apdo. postal 19, Huimanguillo, Tab. 86400 [1]CE Cotaxtla, INIFAP Apdo. postal 429, Veracruz, Ver. 91700, México

In Mexico, the amount of pollinators in cocoa orchards is being considerably reduced by the use of insecticides and the lack of practices that promote the permanence of pollinator insects. In this study we determined the effect of insecticide sprays and the establishment of breeding sites for pollinators (cocoa husks, decayed banana pseudo stems, and a combination of both) on their population density, pollination level, and cocoa dry bean production. It was observed that mortality rate of pollinators was 73% for both insecticides, Monocrotophos (300 g a.i. $ha^{-1}$) and Parathion (500 g a.i. $ha^{-1}$). Even though pollinator insects re-populated the treated area, populations never reached their original levels. Pollination was reduced in 29% to 37% and there was a tendency to decrease dry bean production. Cocoa husks increased pod and dry bean production by 25% and 34%, respectively. The incidence of *Phytophthora* spp. on the pod did not increase.

755 (PS 8)

FREQUENCY OF COCONUT HARVESTING AND COPRA PRODUCTION

Esteban Dominguez-Castillo, José I. López-Arroyo, and J. Angel Saavedra[1]* CE Huimanguillo, INIFAP Apdo. postal 19, Huimanguillo, Tab. 86400 [1]CE Cotaxtla, INIFAP Apdo. postal 429, Veracruz, Ver. 91700, Mexico

From the 26 000 ha planted with coconut palm in the state of Tabasco, only 30% is harvested periodically (every four months). In the rest of the area, growers just pick up the fallen coconuts from the ground with the consequence of a high percentage of germinated fruits. This condition drastically reduces copra quality and quantity. The objective of this study was to find the optimal harvesting span to improve copra yield and quality. Results showed that harvesting the coconuts monthly significatively increased copra yield and number of nuts per palm. This represents increases of 123% and 181% in the number of nuts and kg of copra, respectively per palm $year^{-1}$, as compared with the control. We conclude that more frequent harvests increase the number of nuts and the amount of copra. Conversely, losses caused by fruit germination are reduced.

756 (PS 8)

USING MECHANICAL PRUNING TO MITIGATE ALTERNATE BEARING OF PISTACHIOS

Louise Ferguson and Robert Beede, University of California at Kearney Agricultural Center, 9240 S. Riverbend Ave., Parlier, CA 93648

A single severe mechanical pruning done January, 1985, with the following treatments, hand pruned control, hedging, topping and topping and hedging, successfully reduced the alternate bearing of pistachios. The respective alternate bearing indexes are as follows; control, 0.88; hedged, 0.79, topped. 0.55, hedged and topped, 0.36. All treatments produced approximately equal cumulative yield over the 7 year experimental period. However, the most severely pruned trees demonstrated yield loss in the first 2 years after pruning.

The severe mechanical pruning, done prior to the low crop year, produced its effects by forcing trees to produce less fruiting wood during the off-crop year. The effects of a single severe mechanical pruning persisted 7 years.

757 (PS 8)

POTENTIAL IMPACT OF NITROGEN SOURCE FERTILIZERS ON SURFACE WATER QUALITY

Donald F. Wagner* and Kevin A. Tucker, Department of Horticulture, Clemson University, Clemson, SC 29634-0375

Azalea liners were potted in pine bark and placed in a shaded glass greenhouse at Clemson University. Fertilizer treatments (1) Osmocote 18-6-12 (2) extra coarse IBDU (3) Escote 400 (4) XCIBDU + Escote 400 (1:1) and (5) a control, were top-dressed at the rate of 20 g/pot (3600 mg N/pot) and replicated 5 times in a completely randomized design on 3/26/92. P and K were supplied to treatments 2, 3, 4 and 5; at a rate comparable to that of Osmocote. Weekly leaching started 3/26 for 16 weeks. Visual plant ratings were made, and above ground tissues were analyzed for total N using Kjeldahl digestion. Air and media temperatures were monitored. Osmocote began losing considerable $NO_3^-$-N in leachate within the first few weeks with the losses peaking week 6 then decreasing. The leachate loss curves for the Escote, XCIBDU, and XCIBDU + Escote were similar and peaked around week 12. Total mg of N lost was less for Escote, but the same for the other treatments. Stem dry weights were not different among the 4 main treatments. There was a slight leaf weight advantage of Osmocote over Escote and XCIBDU + Escote. Stem N levels were less in the Escote treatment. Both root and top visual ratings at the termination of the experiment were consumer acceptable. The Escote did exhibit the lowest N leachate levels lost. Reduced N loss could impact the environment positively from this standpoint.

758 (PS 8)

SIMULATION OF VEGETATION GROWTH IN RIPARIAN ECOSYSTEMS

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

Land between agricultural production areas and streams can be important for mitigating pollutants reaching water supplies. However, there is little information available on management for effective control of upland runoff of sediment, nutrients, and pesticides. In an effort to provide a decision-making tool for managing stream-side areas, a riparian ecosystem model has been developed to simulate processes of water movement and nutrient dynamics. An important component of this model is the growth of vegetation. The riparian area is divided into three zones parallel to the stream. In the direction of the uplands, each zone represents an increasing level of management intensity. Vegetation is characterized as grass, an herbaceous/shrub mixture, evergreen trees, or deciduous trees. In forested areas, two canopy layers are simulated in competition with each other for water, light, and nutrients. Photosynthates are dynamically allocated to the plant organs and a reserve pool. Litterfall is a function of biomass and phenology. Vegetation serves to reduce water flow into the stream, act as a physical barrier against erosion, provide carbon for nutrient immobilization and denitrification in the soil, and sequester nutrients in the roots and canopy.

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759 (PS 8)

WATER CONSERVATION PROGRAM

Garald L. Horst, and Donald H. Steinegger*, University of Nebraska, 377 Plant Science Hall, Lincoln, Nebraska 68583-0724

Lincoln, Nebraska is probably ahead of other major municipalities in the Mid-west to initiate water awareness and conservation programs. The average commercial, industrial, or residential water user has a poor concept as to the amount of water their irrigation system applies or water application uniformity. The average Christiansen Uniformity Coefficients (UCC) was 67, with 83% of the UCC values below 80. Almost 80% of the scheduling coefficients were two or greater, meaning that a large portion of landscape water waste from irrigation is hidden from the consumer. An estimate of the potential reduction in water use if the prescribed water conservation program was followed indicated a reduction in water use of 50%. This estimate is drawn from weather station $ET_p$ estimates, lysimeter, and soil water estimates. Crop coefficient ($K_c$) values which take into consideration the plant type were initially at 0.9. Accuracy of this estimate will be noted. Data from the above sources will be presented as well as irrigation uniformity. The impact of "Horace's Water O'Meter" an outgrowth of these findings on landscape water use in Lincoln is discussed.

760 (PS 8)

WATER USE OF GREEN ASH AND NORWAY MAPLE IN TREE SHELTERS DURING ESTABLISHMENT

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

We investigated how tree shelters affected seedling water use as a fractional coefficient of potential evapotranspiration (ETo) and ability to delay water stress in a nursery setting. A field study investigated water relations of newly planted whips with-and-without shelters irrigated at 100% of ETo or unirrigated. Trees in shelters were shade acclimated based on higher specific leaf area, but in diurnal studies had consistently higher stomatal conductances ($g_s$) than non-sheltered trees. Non-irrigated trees with shelters had higher $g_s$ than treatments without shelters. There were no consistent overall differences in water potential ($\Psi$) between irrigation treatments. Predawn $\Psi$ of trees in shelters was more negative, but midday $\Psi$ was similar to non-sheltered trees regardless of irrigation treatment. A separate study placed shelters over foliage of container-grown whips of green ash and Norway maple and enclosed the roots in plastic to eliminate evaporation. Daily gravimetric water use and ETo was followed for six weeks in 1992. Trees in shelters used substantially less water than control trees. Gravimetric water use normalized to depth units varied from 5-10% as a fraction of ETo. This was less than half that of control trees without shelters. Tree shelters reduced water loss while maintaining high gas exchange, but whether shelters helped tree seedlings to delay water stress during establishment was inconclusive from these data.

761 (PS 8)

VARIATION IN AIR CAPACITY AND SATURATED FLOW IN SUBSTRATES WITH INCREASING AGGREGATE ADDITIONS

E. J. Holcomb, Department of Horticulture, The Pennsylvania State University, University Park PA 16802, M.S.Drzal*, and W.C. Fonteno, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695

Little research has been done on water transport in substrates. Research has concentrated on capacity factors such as porosity, air space and container capacity. The objective of this research was to measure both capacity and water transport in peat:vermiculite mixes amended with perlite and rockwool. A device was constructed to measure saturated hydraulic conductivity ($K_{sat}$) of porous substrates using a constant head system with small hydraulic gradients. When 50% peat: 50% vermiculite (v/v) was blended dry and brought to specific mass wetness (MW), perlite substitutions (for vermiculite) of 5, 10, & 20% increased aeration from 5.8 to 9.3%. $K_{sat}$ showed a corresponding increase from 6.49 to 12.18 cm/min. When the peat and vermiculite components were moistened before blending (MW = 3.5 and 1.5, respectively), the same additions of perlite did not produce incremental changes in aeration. However, $K_{sat}$ was markedly increased from 18 to 28.6 cm/min. Water-repellant (WR) rockwool increased aeration only at the 20% addition when mixed dry, but increased aeration significantly at lower rates when blended wet. $K_{sat}$ was not influenced by WR rockwool additions, but was higher in formulations blended wet.

762 (PS 8)

**INTEGRATING AQUACULTURE INTO NURSERY AND TURF FARMS TO IMPROVE WATER AND NUTRIENT USE**

Masud A. Khan*, R.D. Berghage and J.N. McCrimmon
New Mexico State University, Las Cruces, NM 88003

Multiple use of water through integrating aquaculture and irrigated crop production could minimize the cost of rearing fish and irrigating crops. Aquaculture effluent was tested for irrigation of four turfgrass species and Elderica pine seedlings. Plants were irrigated with fish effluent or city water, with or without supplemental fertilization from Osmocote® or Milorganite®. Turfgrass irrigated with effluent gained more biomass and had better color than grass watered with city water. Treatment with supplemental fertilizer resulted in significantly more biomass gain than in untreated turf. A Minolta CR-200 chroma meter was used to determine L, a, b color coordinates and leaf chlorophyll was extracted in DMF (dimethylformamide) and measured with a spectrophotometer. Color coordinate data were correlated with leaf clorophyll content and both were correlated with biomass gain.

763 (PS 8)

OVERHEAD PULSE IRRIGATION REDUCES IRRIGATION RUNOFF AND CONTAINER LEACHATE

D.C. Fare*, C.H. Gilliam, and G.K. Keever, Dept of Horticulture, Auburn University, AL 36849

Overhead pulse irrigation was evaluated as an alternative irrigation practice to reduce container leachate and irrigation runoff. Six irrigation treatments evaluated included 1.25 cm volume applied at 1, 2, and 3 pulses and 0.63 cm volume applied at 1, 2, and 3 pulses with a 1 hr delay between pulses. Irrigation runoff and container leachate were about 50% less in the 0.63 cm treatments compared to the 1.25 cm treatments. There was a 10-14% reduction in irrigation runoff and 29-32% reduction in container leachate when comparisons were made between the 1 pulse and 3 pulse treatments regardless of the irrigation volume applied. Shoot and root growth of Compacta holly were similar among all treatments.

764 (PS 8)

FERTILIZATION AND IRRIGATION AFFECT HOLLY GROWTH

Thomas H. Yeager*
Environmental Horticulture Department, IFAS, University of Florida, Gainesville, FL 32611.

Multiple branched liners of *Ilex vomitoria* were greenhouse-grown in 3-liter containers with a common nursery medium. Each plant was fertilized with 2.5 g N surface-applied as Osmocote (18N-2.6P-10K) and irrigated with 460 ml water twice a week or fertilized with a total of 0.5, 1.0, 1.5, or 2.5 g N from a nutrient solution (6N-1P-3K) and irrigated with 460 ml water twice a week or evapotranspiration (ET) plus 10%, 30%, or 50%. Nutrient solution treatments were divided equally among 26 weekly applications. Shoot dry weights (22 and 25 or 26 and 25 g, respectively) for plants irrigated with ET plus 30% or 50% and receiving 1.5 g or 2.5 g of N were not different and these treatments had larger shoot dry weights (13 and 14 g, respectively) than plants fertilized with 0.5 g of N. Shoot dry weights were similar for plants irrigated with 460 ml water twice a week and fertilized with 2.5 g of N from the nutrient solution or Osmocote. Shoot dry weights of plants irrigated with ET plus 30% or 50% were similar to plants irrigated with 460 ml water twice a week when plants received 1.0, 1.5, or 2.5 g of N.

765 (PS 8)

INTERMITTENT SPRINKLER IRRIGATION INCREASES IRRIGATION APPLICATION EFFICIENCY

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

Experiments were conducted to determine if applying a container-grown plant's daily water allotment in multiple applications (intermittently) increased application efficiency relative to the allotment applied in a single application (continuous). Water was

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applied (simulated overhead sprinkler system) to marigold plants in a pine bark substrate. Time interval between intermittent applications and water movement in the substrate were investigated. Application efficiency was greater when the water allotment was applied intermittently compared to a single application. Efficiency was also greater when the interval between applications was increased from one to two h. Sectioning substrate into top, middle, and bottom thirds showed that the bottom layer of the intermittent treatment contained more water than the bottom layer for the continuous treatment. There were no differences in water content in the top and middle layers between the two treatments.

766 (PS 8)

DESIGN AND OPERATION OF AN AUTOMATED CAPILLARY IRRIGATION SYSTEM FOR PRODUCTION OF CONTAINERIZED NURSERY PLANTS.

Peter R. Hicklenton* and Kenneth G. Cairns, Agriculture Canada, Research Station, Kentville, N.S. B4N 1J5.

Capillary irrigation uses less water than most other methods, and effectively reduces the quantity of fertilizer leaching from nursery containers. We have developed a sand bed system with automatic control of bed hydration using inexpensive and readily available analog hardware. Water supply to the sand bed (via irrigation drip hose) is controlled by a bridge-type temperature controller associated with two stainless steel mesh sensors embedded in the sand. Growth, quality and nutrient status of capillary (CI) or drip-irrigated (DI) *Juniperus horizontalis* 'Plumosa Compacta' (Andorra juniper) and *Euonymus fortunei* 'Coloratus' were compared in 2 consecutive growing seasons. At the end of the second year CI Juniper and Euonymus plants were 23% and 37% larger, respectively, than their DI counterparts. Foliar N did not differ between irrigation regimes in Juniper, but both P and K levels were higher in CI plants; foliar N, P, and K, were consistently higher in CI Euonymus.

767 (PS 8)

**MICROCLIMATE MODIFICATION CAN IMPROVE THE GARDEN PERFORMANCE OF BEDDING PLANTS**

Virginia I. Lohr* and Caroline H. Pearson-Mims, Department of Horticulture and Landscape Architecture, Washington State University, Pullman, WA 99164-6414

The use of small, open, landscape fencing to improve bedding plant growth under reduced irrigation was examined. Field-grown bedding plants were irrigated to saturation once every two weeks. Wooden fences, 0.5 m tall with 29% porosity, were installed in the planting beds. Plants adjacent to the fences were compared with plants growing without fencing.

The addition of the fences appeared to create a microclimate that favored plant growth. Wind speed adjacent to the fences was reduced up to 50%, depending on the velocity and direction, from speed in open areas. Stomatal conductance and transpiration were higher for plants growing next to the fences compared with those away from the fences. Plants adjacent to the fences were up to 10% larger than plants grown in the open.

768 (PS 8)

CONTROLLED ENVIRONMENT CONSTRUCTED WETLAND TREATMENT OF GREENHOUSE DRAINAGE

Christopher H. Pickerell* and Robert W. Langhans, 20 Plant Science Building, Cornell University, Ithaca, NY 14853

Constructed wetlands have been used to treat many types of aqueous wastes. This innovative plant-based technology is ideally suited for use in the greenhouse horticulture industry given high levels of nutrients in irrigational runoff and drainage and the horticultural experience of greenhouse managers. Use of small-scale systems under controlled environment conditions could provide efficient and reliable year-round drainage remediation at minimal cost. Four identical 0.5m$^2$ recirculating wetland tanks planted with Iris pseudacorus were used to treat simulated greenhouse drainage high in nitrate and other salts. Percent removal for batch-wise treatment was measured by determining concentration changes for ions in a constant volume. Nitrogen removal ranged from 87.3 to 96.7% with 7 day retention times for plant uptake experiments. Greater than 90% removal of phosphorus and potassium was achieved with 1 day and 5 day retention times, respectively. Sodium removal ranged from 13 to 60%. aluminum, boron, calcium, iron, magnesium, manganese, sulfur, and zinc were reduced appreciably within 7 days of recirculation. Treatment efficacy did not decrease over the 10 month study. Denitrification experiments using sucrose to induce anaerobic conditions showed greater than 90% nitrogen removal within 24 hours. Overall, the results were encouraging for the use of this technology in treating horticultural drainage.

769 (PS 8)

EFFECT OF LEACHATE FRACTION AND WETTING AGENT ON THE SOIL $NO_3$-N PROFILE UNDERLYING A GREENHOUSE CROP

Richard J. McAvoy, Department of Plant Science, University of Connecticut, Storrs, CT 06269-4067.

Chrysanthemums, cultivars Red Grenadine and Buckaroo, were produced in 15 cm pots in the greenhouse and fertilized with a 210 mg/l N solution at a volume of either 550 ml or 1000 ml. The nutrient solution applied to half the pots contained a wetting agent (AquaGro L), the remaining pots received no wetting agent. Soil core samples were removed, at 15 cm increments to a depth of 90 cm, from the soil profile underlying each treatment group. Leachate samples were collected and the volume and $NO_3$-N content determined. Final and mid-term plant dry weight were determined, and the tissues (leaves and flowers) were analyzed for $NO_3$-N and total nitrogen content. The leachate fraction (LF) from pots receiving a wetting agent (WA) was greater ($p < 0.05$) than from pots receiving no WA (29.1% vs 26.4% respectively). However, WA did not greatly affect the amount of $NO_3$-N in container effluent or the total $NO_3$-N deposited on the soil underlying the crop; these were most influenced by LF. $NO_3$-N content in the upper 15 cm soil zone under pots irrigated to a high LF was higher than under the low LF pots after two weeks and by week 10 (end of the study) significant differences were measured in the 30-45 cm soil zone. At final harvest, significant differences in plant dry weight, potting medium $NO_3$-N, and plant total N content were observed in response to both LF and WA treatments.

770 (PS 8)

THE MOVEMENT OF ISOXABEN IN CONTAINER NURSERY RUNOFF WATER.

C. Wilson*, T. Whitwell, and M. Riley; Department of Horticulture, E-142 P&A's Building, Clemson University, Clemson, SC 29634-0375.

Container nurseries broadcast apply granular formulations of herbicides over-the-top of container crops and then apply irrigation. Depending upon spacing and plant architecture, up to 80% of the applied herbicide may land on the surfaces surrounding containers where it is then available to move offsite in irrigation runoff water. This study measured the amounts of isoxaben and trifluralin (from Snapshot 2.5TG) lost from a container nursery site during an irrigation event and monitored the dissipation of each in containment pond water. A 1.22 hectare container nursery production area was treated with Snapshot TG at 112 kg product/hectare and 1.27 cm irrigation was applied. Water samples were collected from the runoff water before it entered into the collection pond at the following time intervals: 0.25, 0.5, 1.5, 2.5, and 3.5 hours after runoff began. Water samples were also collected in the containment pond before treatment, after treatment, and then 1-3, 5, 7, 14, 29, and 60 days after treatment. Nearly 17% of the applied isoxaben was lost in the runoff water immediately following application. Isoxaben concentrations in the containment pond water decreased from a high of approximately 30 ppb immediately following the first runoff event to below 1ppb 60 days after application. No trifluralin was detected in the runoff or catch pond water.

771 (PS 9)

DESIGN AND OPERATION OF A SIMPLE HYDROPONIC SYSTEM AS A TEACHING AID FOR HORTICULTURAL SCIENCE

Stephen Garton*, Dept. Plant & Soil Science, Alabama A&M University, P O Box 1208, Normal AL 35762

A hydroponic apparatus consisting of a nutrient solution reservoir, inert flotation platform containing perforated thimbles, which project through the platform was used to grow plants. The plants were started from either seeds or vegetative structures (stem cuttings, tissue cultured plantlets, leaf laminae, etc.) The apparatus is self-contained and requires no additional aeration since the design of the platform allows development of roots both in air and water. The apparatus has potential application as a research tool and in teaching plant nutrition, introductory plant science, and plant propagation.

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772 (PS 9)

ANALYZING PERCENTAGE DATA

Richard P. Marini* and Michele Choma Marini, Department of Horticulture, Statistics Department, Virginia Polytechnic Institute & State University, Blacksburg, Va. 24061-0327

Data generated from horticulture experiments often are expressed as percentages. Since these data may not approximate normality, we often automatically transform the data before analysis. Is this automatic transformation always correct? Non-transformed data may already approximate a normal distribution. Should these data be transformed? What does transforming a normal data set do to it? To address these questions, a real data set was used to check the assumption of normality and examine regression models before and after transformation of normal and non-normal percentage data. Transformations include both standard arcsin of the square root of the proportion and a log (log) transformation. We will show that transforming normal data can make it non-normal and alter conclusions. Testing assumptions before and after transformation will be emphasized. The SAS procedures GLM and UNIVARIATE will be used to generate output and demonstrate results of normality tests and different conclusions resulting from unnecessary transformations.

773 (PS 9)

THE VIRGINIA TECH TRANSPLANTED MEADOW: AN ALTERNATIVE TO DIRECT-SEEDED MEADOW CULTIVATION.

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

The Virginia Tech Transplanted Meadow (VTTM) concept was developed in response to weed control and limited aesthetic beauty problems associated with direct-seeded meadows. VTTM retains low fertility, drought stress, and soil adaptability characteristics while greatly reducing weed invasion and extending site beauty via simple methodology. Equal seed quantities of eight to twelve annuals are combined and sown in 10x10 cm packs in the greenhouse on May 1. Thirty days later, seedlings receive 475 ppm N and are transplanted as blocks at 12" spacing in a rototilled (8") site. Blocks are mulched and watered; irrigation continues only as needed for 2-4 weeks. No additional fertilizer is applied. Flowering continues up to frost and VTTM is repeated the next year(s). The poster will photographically document the VTTM technique and its performance in a variety of settings over five years of trials, including evaluations in urban, interstate highway, and formal garden environments.

774 (PS 9)

BRINGING EXPERIENTIAL LEARNING TO THE CLASSROOM

Dan T. Stearns*, Perry M. Morgan, and Julie R. Lehman, Department of Horticulture, Pennsylvania State University, University Park, PA 16802

Experiential learning has proven to be a valuable component of the Landscape Contracting curriculum in Penn State's Department of Horticulture. Implemented in four classes, two with design orientation and two with construction orientation, experiential learning has been utilized to stimulate and encourage critical thinking among students, both individually and in group situations. This teaching method serves to ignite student interest in further exploration of both concepts and process. Students involved in experiential projects have taken initiative to go beyond problem statement requirements to expand project scopes and elevate the quality of finished products. Indications of exceptional student motivation include requests by course enrollees for additional work to further develop design concepts, and organization of work sessions outside of class time to accommodate expanded work objectives. Successful integration of experiential learning into course outlines requires instructor skills that differ substantially from those employed in traditional lecture or studio formats.

775 (PS 9)

A SURVEY OF RECENT GRADUATES OF LANDSCAPE CONTRACTING

Dan T. Stearns* and Paige M. Thomas, Department of Horticulture, Pennsylvania State University, University Park, PA 16802

In a survey of 42 recent graduates of the Penn State Department of Horticulture's Landscape Contracting major, 29 respondents indicated their present employment, salary range, and the type of work in which they were involved. 25 were employed by landscape contracting firms, 1 by an irrigation design firm, and 3 were attending graduate school. Salaries ranged from a low of $12,000 to $15,000, to a high of $30,000 to $35,000, with average just below $20,000. 19 were involved in landscape installation, while 14 were doing landscape design and 14 maintenance. Work in pest control and irrigation were each identified by 6 respondents. The survey requested identification of four areas important to their employment that were not adequately addressed in the curriculum. Equipment handling and repair and pest control received the greatest response. Also requested was identification of four aspects of the curriculum that were most useful to them in their employment. Design, plant identification, and construction practices received the greatest responses in this category.

776 (PS 9)

"LIVING DISPLAY": A NEW APPROACH TO DISSEMINATING CONSUMER-HORTICULTURE INFORMATION

Vicki L. Morrone* and J. Robert Nuss, Penn State University, 102 Tyson Bldg., University Park, PA 16802

The Agriculture Cooperative Extension is increasingly involved in programs that reach out to new audiences to provide information on horticulture and environmentally aware practices. Numerous types of educational displays and demonstrations are used to provide information and create enthusiasm for the topic. Most approaches use static, visual displays. A key factor toward creating a successful display for a lay audience is its entertainment value. A "living display" is a new approach, which entertains and catches the eye of the passing observer and provides information on the featured topic. The "living display" features three-dimensional information and actors that mime the "how-to's" and the benefits of the educational material. We will demonstrate the use of a living display by The Master Gardeners of Pennsylvania entitled "The Splendors of Composting"- a display oriented toward persons of all ages. It introduces how to create a back-yard compost and presents the benefits derived from composting. Data on audience response to this display will be presented.

777 (PS 9)

WINDBREAK ESTABLISHMENT THROUGH DEMONSTRATION AND EDUCATION

Vern C. Quam*, Department of Horticulture and Forestry, North Dakota State University, Fargo, ND 58105

Windbreaks are an essential part of rural and urban living in the northern Great Plains. They provide protection to crops and livestock from wind by modifying windchill factors, lowering soil erosion, and conserving soil moisture. Around farmsteads and cities, benefits include energy conservation, control of snow deposits, and added aesthetic values. In urban centers windbreaks are important as aesthetic screens, living snow fences, noise barriers, and sites of air filtration.

Tree establishment on the prairies can be challenging with low rainfall and cold winter temperatures. A windbreak demonstration program began in 1989 across the state of North Dakota. The demonstration program is a joint effort between local soil conservation districts, extension service, and 275 landowners. The demonstrations were designed to compare new and traditional tree establishment techniques. The program goal is to gather data from various demonstration sites and transfer the information to land owners, thereby increasing tree survival and establishment in windbreak plantings.

778 (PS 9)

ENCLAVE EMPLOYMENT AT VIRGINIA COLLEGE AND UNIVERSITY GROUNDS DEPARTMENTS

Gerald S. Dobbs* and Paula Diane Relf, Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0327.

In 1991 and 1992, two surveys were developed and sent to 87 Virginia colleges and universities to ascertain the most effective method of employing individuals with mental disabilities within their grounds departments. There were 62 (71%) responses to the surveys. The surveys show that 21 (34%) colleges and universities have employed or currently employ individuals with mental disabilities within their grounds departments (total of 67 individuals). Currently, 11 (18%) college and university grounds departments employ 27 individuals with mental disabilities. Of these, four colleges and universities employ 20 (74%) as members of enclaves.

There were 25 individuals previously or currently employed as members of an enclave; 20 (80%) were still employed in 1992. There were 42 individuals previously or currently employed as individual employees by the grounds departments; 7 (16%) were still employed in 1992. Based on these surveys, the enclave model of employment appears to be the most successful for continued employment of individuals with mental disabilities within Virginia college and university grounds departments.



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779 (PS 9)

POINT OF PURCHASE BROCHURES FOR EXTENSION CONSUMER HORTICULTURE EDUCATION THROUGH RETAIL GARDEN CENTERS

Paula Diane Relf*, Robin Rogers, and Joyce Shelton, Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0327.

A series of 20 informational brochures has been produced cooperatively by representatives from five departments and the horticulture industry. These brochures focus on environmentally sound, residential landscape practices. The brochures are designed for purchase by retail garden centers, nurseries, and landscape contractors for distribution to their customers, providing educational information and freeing employee time from answering questions. An order blank has been prepared, and the material is being promoted through the Virginia Nurseryman's Association and state and regional trade shows. Topics covered are planting shrubs, planting trees, making compost, using compost, storing pesticides, choosing pesticides, pesticide labels, integrated pest management, pruning trees and shrubs, applying pesticides, healthy soil, water-wise landscaping, diagnosing plant problems, fertilizing trees/shrubs, landscaping for less in the landfill, maintaining lawns, establishing lawns, choosing turfgrass, fertilizing lawns, and selecting hand tools.

780 (PS 9)

PHENOMENOLOGICAL INTERVIEWING: A USEFUL RESEARCH TOOL FOR THE HORTICULTURE INDUSTRY

Susan L. Wilson*, Department of Ornamental Horticulture and Landscape Design, University of Tennessee, Knoxville, TN 37901-1071

Many research methods are available for horticulturists to use in obtaining information about a target audience. Most methods used (eg. surveys and questionnaires) are quantitative in nature in that they provide numerical data on statistical generalizable patterns.

Phenomenological interviewing is a qualitative research method which allows investigators, through open-ended interview questions, to obtain more in-depth data than traditional quantitative techniques. This research method allows investigators to understand and capture the points of view of the participants without predetermining those points of view through prior selection of questionnaire or survey categories. This research approach is used extensively in the social sciences and has implications for those working in horticulture.

To provide an understanding of the phenomenological interviewing approach as it could be used in horticulture, examples from a pilot study done on visitors to the University of Tennessee Research Gardens will be provided.

781 (PS 9)

BIOTECHNOLOGY: SCIENCE AND SOCIO-ECONOMIC ISSUES

S.L. Kitto[1]*, C.K. Halbrendt[2], L.G. Sterling[3], Dept. [1]Plant and Soil Sciences, University of Delaware, Newark, DE 19717. [2]Dept. of Food and Resource Economics. [3]Dept. of Animal Science and Agricultural Biochemistry.

An introductory, multidisciplinary course entitled "Biotechnology: Science and Socio-Economic Issues", designed to introduce students to the issues associated with biotechnology, has been taught five times during the past four years. Lectures on the basic science, practical applications, ethics, regulations, and economics of biotechnology were presented by experts from academia, government and industry. In an effort to evaluate the impact of education/knowledge on acceptance of biotechnology as it relates to plants and/or animals, students were surveyed the first and last days of the semester. Survey findings will be discussed.

782 (PS 9)

THE MARYLAND-DELAWARE MASTER GARDENER MANUAL, A NEW TRAINING MANUAL

Denise D. Sharp, Susan S. Barton and Jon H. Traunfeld*, University of Maryland, Home and Garden Information Center, 12005 Homewood Road, Ellicott City, MD 21042

The Maryland-Delaware Master Gardener Manual has been printed. Twenty two chapters were written by Maryland and Delaware agents and specialists. Each chapter is designed to stand alone for use in short courses and can be purchased independently of the manual. The entire manual is in a three-ring binder. For states interested in using the Maryland-Delaware format but rewriting sections to reflect their geographic area, disk copies are available. The flexible style and content of the manual will be highlighted and appropriate ordering information will be available. The educational format offers opportunities beyond traditional master gardener classes.

783 (PS 9)

A LABORATORY EXERCISE IN QUANTITATIVE COLOR DETERMINATION

S. Singha* and B. B. Bible. Department of Plant Science, University of Connecticut, Storrs, CT 06269-4067

Portable tristimulus colorimeters allow precise documentation of color of horticultural commodities and their usage in research is increasing. This laboratory exercise was designed to familiarize students with CIELAB color space coordinates and the relationship between quantitative values and visual color ratings. Students measured L* a* b* coordinates and used these values to compute and comprehend derivatives including hue angle, chroma and color difference. These concepts were demonstrated using readily available materials including bananas at different stages of maturation, apples harvested from different canopy locations, and variations in rate of oxidative browning of the flesh of apples stored at different temperature. To develop an appreciation for both quantitative and qualitative color measurements leaves of varying color were visually rated, matched to Royal Horticultural Society color charts and L* a* b* values measured with a Minolta CR-200b Chroma Meter.

784 (PS 9)

ADAPTATION OF FAST PLANTS® AS MODEL ORGANISMS FOR HANDS-ON INSTRUCTION OF FUNDAMENTAL CONCEPTS IN HORTICULTURE

Sharon Treaster*, Michael Knee and Pablo Jourdan, Department of Horticulture, The Ohio State University, Columbus, OH 43210-1096

The Wisconsin Fast Plants® (rapid cycling forms of *Brassica rapa*) have become a major educational tool in basic botany, plant physiology and plant genetics courses because of their versatility, ease of manipulation, and short life cycle (40-day generation). Various educational activities already developed by the Fast Plants Network can be incorporated effectively into established horticulture courses. We have been utilizing these plants in some of our introductory courses and have developed additional protocols and materials. Some of the new educational activities utilize the rapid cycling form of *B. oleracea*. Examples of these materials will be presented, including: new genetic stocks and use of isoenzyme markers; use of growth regulators (e.g., uniconazole) to modify plant growth and development; post-harvest physiology (e.g., growth, chlorophyll and starch content); hydroponics and plant nutrition; cell and tissue culture (micropropagation, anther culture, protoplast culture, transformation); and biochemical studies (e.g., enzyme isolation and characterization, extraction and characterization of DNA, etc).

785 (PS 9)

USING DIGITIZED IMAGES IN HORTICULTURE

James McConnell*, Frank J. Cruz, and Mari Marutani, College of Agriculture and Life Sciences, University of Guam, UOG Station, Mangilao, GU 96923

The uses of images digitized from slides and video, in Horticulture, were explored. With the improving quality of video capture boards for computers and the availability of photo CDs, it is becoming increasingly feasible to use these images in research, extension, and education. Video capture and digitized slide images were used for producing colored handouts, computer databases, computer aided instruction and image analyses. Demonstrations can be recorded and digitized for use in handouts and videos.

Currently, thermal wax color printers produce acceptable quality images for handouts and information sheets. The cost per print is much less than dye sublimation printouts. The advantage to having a color printer is the ability to print sheets as needed allowing many information sheets to be produced without the need to store large numbers of documents.

Image analysis can be enhanced by using filters. Command sequences can be recorded to automate the measuring of various morphological characteristics from the digitized images. Many measurements can be made non-destructively allowing for in field measurements. Image subtraction can be used to remove field backgrounds from the images. Plants moving in the wind can be recorded at a faster shutter speed to freeze the motion.

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786 (PS 9)

A LABORATORY EXERCISE TO ILLUSTRATE ASPECTS OF BIOLOGICAL $N_2$ FIXATION TO PLANT SCIENCE STUDENTS

William R. Graves*[1] and Lorna C. Wilkins[2]

[1]Department of Horticulture, Iowa State University, Ames, IA 50011

[2]Department of Horticulture, University of Maryland, College Park, MD 20742

A laboratory exercise on biological $N_2$ fixation (BNF) using two diverse legume species was developed. Students plant surface-sterilized seeds of *Robinia pseudoacacia* L. and *Glycine max* (L.) Merill together in plastic pots with a sterile medium. Pots are assigned to one of six treatments. Pots in treatments A, B, and C are irrigated with a solution lacking nitrogen, whereas those in D, E, and F receive a compete solution. Seedlings in treatments A and D are inoculated with a strain of *Bradyrhizobium*, and seedlings in B and E are inoculated with a strain of *Rhizobium*. Development of plants is monitored before a destructive harvest 7 weeks after inoculation. Results illustrate host plant-rhizobial specificity, the inhibition of nodulation by nitrate, and that dependency on BNF reduces growth compared with plants receiving nitrate.

787 (PS 9)

MARKETING CUT-ORCHIDS TO THE TOURIST TRADE

John W. BROWN* and James McConnell, Agricultural Experiment Station, University of Guam, Mangilao, Guam 96923, USA

Selling cut-flowers to the tourists visiting a vacation location offers an additional outlet to local growers of orchids. Advantages include a shorter marketing channel, higher local prices and the avoidance of airfreight costs and tariffs. Disadvantages include higher direct marketing costs including such items as packaging, promotion and access to the tourists, phytosanitary problems and lack of knowledge about tourists preferences for different flower cultivars and colors. This paper presents the results of a survey of the direct marketing of orchids to tourists in Honolulu, Bangkok, Phuket, Kuala Lumpur and Singapore. Pricing strategies, access to tourists and phytosanitary problems are discussed.

788 (PS 9)

DO PLANTS AFFECT HUMAN BEHAVIOR IN INTERIOR SPACE?

Cathy Hillenbrand-Nowicki, Jeanette Bowker, and Paula Diane Relf*, Dept. of Housing, Interior Design, and Residential Management and Dept. of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

Plants traditionally are used by interior designers as complementary natural components of the interior. This study attempts to identify if plants, in addition to providing visual interest, affect the spacial perceptions and behaviors of users in close proximity to them. The study was conducted in a three-level atrium built as part of an in-fill expansion project. Seating on the lowest level was used infrequently, and the total atrium was perceived as relatively unattractive. Changes in user perception and seating choices after the installation of 15-foot *Ficus benjamina* and 6-inch pots of Chinese evergreen plants on the lower level were measured. Findings could be a useful tool in redefining the use of plants in interior design and a tool for market development for the interior plantscape industry.

789 (PS 9)

CONSUMER ACCEPTANCE OF SPECIALTY CUT FLOWERS

Karen Gast* and Alan Stevens, Department of Horticulture, Forestry, and Recreation Resources, Waters Hall, Kansas State University, Manhattan, KS 66506.

Specialty cut flowers or "old fashion garden flowers" include all decorative plant materials except roses, mums and carnations. These were commonly found in the trade over fifty years ago, but lost favor because of short vase lives and a centralization of flower production in the country and a movement of it overseas. We are now seeing a resurgence of specialty cut flower production but have a generation or two of consumers who are unfamiliar with them. The purpose of this study was to acquaint consumers with various specialty cut flowers and evaluate their acceptance. Small desk size bouquets and large bouquets were evaluated, which was done once a week for four weeks. Each week the shape and form of the bouquets changed as did the plant material. Over ninety percent of the respondents said they would include specialty cut flowers in their next flower purchases but were non committal about a preference of them over traditional cut flowers. The large bouquets seemed to produce the greatest impact but both sizes seemed to improve the work environment.

790 (PS 10)

EFFECT OF LOW TEMPERATURES ON FRUIT QUALITY IN MELON (*CUCUMIS MELO* L.)

Yvonne Rosengartner[1,2]*, Dudy Bar-Zvi[2] and Samuel Mendlinger[1], [1]Institutes for Applied Research, [2]Department of Life Sciences, Ben-Gurion University of the Negev, P.O.B. 1025, Beer-Sheva, Israel

Within a program determining the response of melon plants when grown at suboptimal cold temperatures, fruit quality was examined in 20 cultigens grown under two temperature regimes. The cultigens included open pollinated and hybrid cantaloupes and honey dews. The two temperature regimes were: (i) heated greenhouse, at minimum and maximum temperatures close to commercial cultivation requirements, and (ii) unheated greenhouse, at a temperature 7-8°C lower than the former, representing a major cold stress. The parameters examined included fruit appearance and marketability (weight, size, netting) as well as fruit constituents (sucrose, glucose, reducing sugars, TSS, pH, EC, titratable acidity). Cold stress was found to improve some parameters, but impair others. The low temperatures significantly reduced fruit weight and size, but increased fruit number per plant, sucrose and TSS in most but not all cultigens. Significant interaction was found between the temperature regimes and cultigens in these parameters. The results strongly indicate that genetic variation exists in melons for response to low temperature, and therefore that potential for breeding melons for cold stress is present.

791 (PS 10)

INFLUENCE OF TEMPERATURE ON STABILITY OF PLANT ARCHITECTURE OF DRY BEANS (PHASEOLUS VULGARIS L.) AND IMPLICATIONS FOR SELECTION

Yen-Yao Sung, Dermot P. Coyne*, Dale T. Lindgren and David S. Nuland, Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724

Upright, unstable Great Northern (GN) and Pinto (P) dry bean lines (Type IIb) have been developed in Nebraska (NE). The influence of temperature (T) under a long photoperiod (PH) on architype was investigated. A split-plot design, with 3 T regimes (PH, 15 hrs. light, 9 hrs. dark) as main-plots and 5 lines as sub-plots, with 3 replications, were used in growth chambers (GCs). Twenty-two bean lines were planted in a RCBD with 4 replications at each of 3 field locations in NE (1991, 1992). A significant interaction of lines x T regimes for branch number was observed in the GCs. Some lines developed more branches under 28C light/20C dark than under lower T regimes. Significant interactions between lines x locations, lines x years were detected for branch number, plant upright-ness, plant height and days to flowering and maturity. Most lines had less branches and were more upright at lower T. Lines need to be screened under high T and long PH to select for architectural stability.

792 (PS 10)

SUSCEPTIBILITY OF DRY EDIBLE BEANS TO LEAFHOPPER INJURY

Dale T. Lindgren* and Dermot P. Coyne, Department of Horticulture, University of Nebraska, Lincoln, NE 68583-0724

Twenty-two lines of dry edible beans, *Phaseolus vulgaris*, were rated for leafhopper (*Empoasca fabae*) injury in 1991 in field plots near North Platte, NE. Lines were re-evaluated in 1992 in a split-plot design in protected (insecticide applied) and unprotected treatments. There were significant differences for yield, leafhopper counts, and leafhopper injury between 1) protected and unprotected treatments, 2) lines and 3) for protection x lines interaction. There were significant correlation coefficients between insect number (-0.44**) and plant injury (-0.46**) with yield in the unprotected treatments, but no significant correlations in the protected treatments. Average insect counts on three trifoliate leaves on the 22 lines ranged from a low of 2.3 to a high of 32.0 in the unprotected plots. There was a significant difference in seed size and seeds/pod but not for pods/plant for protected versus unprotected treatments. The studies suggest leafhoppers have a much greater preference for some bean lines than others. This should be a consideration when breeding/selecting bean lines for locations where leafhoppers are prevalent.



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793 (PS 10)

**DEVELOPMENT OF A CULTURAL SYSTEM FOR COMPACT GROWTH HABIT FRESH-MARKET TOMATO LINES.**

Joseph M. Kemble*, Jeanine M. Davis and Randolph G. Gardner, North Carolina State University, Mountain Horticultural Crops Research and Extension Center, 2016 Fanning Bridge Rd., Fletcher, NC 28732-9244.

Staked, fresh-market tomato production in the southeastern US is intensive and involves a high level of inputs. Labor costs, for the hand operations of staking, pruning and tying, constitute a large portion of these inputs. Compact growth habit tomato lines are being developed to replace standard determinate cultivars. Plants with this growth habit do not require pruning, staking or tying, and when grown in double-rows on plastic-covered beds, produce high early-season yields. Since a large number of transplants are required for double-row plantings, the use of high-density planter flats was studied. The influence of planter flat cell volumes (ranging from 3.3 $cm^3$ [highest plant density] to 80 $cm^3$ [lowest plant density]) and transplant age (4- and 5-weeks-old) on flowering and early marketable yields was examined. In 1991 and 1992, highest early marketable yields (19,171 kg/ha and 23,743 kg/ha, respectively) were obtained with the oldest transplants produced in the 80 $cm^3$ cells. With 37 $cm^3$ cells, however, larger quantities of transplants could be produced with a minimal delay in maturity and loss in yields. A complete cultural system, from transplant production to harvest, is proposed for use of these compact growth habit tomato lines for early-season fresh-market tomato production.

794 (PS 10)

BACTERIAL WILT-TOLERANT SOMACLONES OF TOMATO (LYCOPERSICON ESCULENTUM Mill.).

Carol A. Bobisud*, Susan P. Martin and Terry T. Sekioka, University of Hawaii, Kauai Research Station, 7370-A Kuamoo Road, Kapaa, HI 96746.

Somaclones of tomato cultivar 'Healani' were tested in a bacterial wilt infected field. Eighteen lines were found to be tolerant of bacterial wilt. Field testing of 'Healani' and the bacterial wilt tolerant somaclonal lines showed character differences in some of the lines. Significantly lower yield than 'Healani' was found for all somaclonal lines. Diameter of the fruit was significantly smaller in seven of the lines, while pericarp thickness was significantly less in seventeen of the lines. In seven of the lines, fruit locule number was significantly greater than 'Healani' fruits. Generally, the occurrence of radial cracks and concentric cracks appeared to be greater in the somaclonal lines.

795 (PS 10)

FRUIT AGE, PERIOD OF FRUIT AND SEED STORAGE, AND FERMINATION AFFECT EMERGENCE OF PUMPKIN

Leonel Lepe and Linda Wessel-Beaver*, Depts. of Horticulture and Agronomy and Soils, College of Agricultural Sciences, University of Puerto Rico, Mayaguez, PR 00681

The effect of fruit age (30 to 50 days after anthesis), fruit storage (seed extracted 0 to 20 days after harvest), and seed storage (0 to 12 months) on seed weight, emergence and vigor were studied in two tropical populations of pumpkin (*Cucurbita moschata*). In separate experiments fermentation of extracted seed was studied using several tropical and temperate genotypes. Emergence reached nearly 100% in seeds from fruit harvested 45 days after flowering, no matter how many days these fruits were stored. Seed weight and emergence markedly increased for seed extracted from less mature fruit (harvested 30 to 45 days after anthesis) when those fruits were stored for 15 to 20 days after harvest. Emergence improved during the first 3 months of seed storage, then leveled off during the remainder of the study. Fermentation of the seed and placental material for 48 hrs followering extraction does not damage seed. The seed extraction process is simplified and the emergence rate appears to increase possibly due to faster imbibition in fermented seed.

796 (PS 10)

TENDRILS AS AN ALTERNATE TISSUE SOURCE FOR CHROMOSOME VISUALIZATION

R.C. Yadav* and R. Grumet Horticulture Department, Michigan State University, East Lansing, MI 48824

Cytogenetic analysis of plants is most frequently performed using root tip squashes. However, roots are not always readily available. As an alternative approach to verify the ploidy level of our transgenic melon (*Cucumis melo*) plants we tested the possibility of using meristematic tissue at the tip of growing, young tendrils. A procedure has been developed to visualize the chromosomes in melon and cucumber. The cytological technique included fixation of young tendrils for 24 hours in acetoalcohol (1:3) or carnoy's fluid followed by hydrolyzing in IN HCl for 10 min at 60°C. The tips were then squashed in 0.5% acetocarmine. The procedure yielded well separated chromosomes of the two species. We are now testing whether this technique can also be utilized for visualizing chromosomes of other tendril bearing plants e.g. peas, grapes.

797 (PS 10)

COMPARISON OF SCREENING METHODS FOR EVALUATING RESISTANCE OF SWEETPOTATO CLONES TO *STREPTOMYCES IPOMOEA*.

Petra J. Wolters* and Wanda W. Collins, Department of Horticultural Science, North Carolina State University, Box 7609, Raleigh, NC 27695-7609

*Streptomyces ipomoea* is the causative agent of a destructive disease of sweetpotato called Streptomyces soil rot or pox. Efforts to incorporate resistance to *S. ipomoea* into new cultivars have been limited by the need to make evaluations in naturally infested fields, which are seldom large or uniform enough for such evaluations. In this study three different methods for evaluating clones in the greenhouse or laboratory were compared: 1) root slices dipped into a *S. ipomoea* suspension, 2) terminal vine cuttings planted in a vermiculite-broth carrier containing aerial mycelia and spores of the pathogen, and 3) one internode long, rooted cuttings planted in tissue culture boxes containing the previously mentioned carrier. Preliminary results using five sweetpotato clones indicated that correlations between data from the three methods were moderate to high (r=0.31 to 0.99). Correlations found between data from method 1 and 2 were higher (r=0.65 to 0.99) than between data from either method 1 and 3 (r=0.41) or method 2 and 3 (r=0.31 to 0.68). These results suggest that method 3 may be less reliable for evaluating resistance of sweetpotato clones to infection with *S. ipomoea* than method 2 or 3.

798 (PS 10)

GENOTYPIC VARIATION IN BROCCOLI FOR TOLERANCE TO THE HERBICIDE OXYFLUORFEN APPLIED AT POST-TRANSPLANT AND PREEMERGENCE STAGES

Mark W. Farnham* and Howard F. Harrison, USDA-ARS, U. S. Vegetable Laboratory, 2875 Savannah Hwy., Charleston, SC 29414

Oxyfluorfen has been recently labeled for use as a pre-transplant herbicide for use in cole crops. Potential susceptibility to oxyfluorfen injury limits the situations in which this herbicide can be utilized. In a preliminary screen of broccoli cultivars, we observed variable responses to oxyfluorfen applied post-transplant. Two susceptible cultivars, Early Dawn and Green Goliath, were further tested with two tolerant cultivars, Emerald City and Pinnacle, to characterize differences in tolerance. Oxyfluorfen was applied to 3-leaf stage transplants at rates of 100, 200, 400, 800, and 1600 kg/ha in greenhouse and field trials. In addition, preemergent treatment with oxyfluorfen was tested by applying the herbicide immediately following the seeding of pots. The effect of the herbicide was assessed by rating foliar damage (0-9) and by fresh weight measurement taken 2-3 weeks after treatment. At all rates of application with both transplant and preemergent treatments Pinnacle exhibited the greatest level of tolerance exhibiting the least foliar damage and reduction in fresh weight. Green Goliath was very susceptible to oxyfluorfen injury while Early Dawn and Emerald City had intermediate responses.

799 (PS 10)

VARIETAL DIFFERENCES OF POWDERY MILDEW RESISTANCE IN MELON

Keita SUGIYAMA* and Tsuguo KANNO, Kurume Branch, Natl. Res. Inst. Veg., Orn. Plts & Tea. 1823, Mii, Kurume, Fukuoka, Japan 830

Varietal tests of powdery mildew resistance in melon were performed in glass house in 1992, by using of susceptible varieties(S), resistant varieties in Japan(R1) and an American resistant line and its related lines(R2).

The first test(August): S type was infected the most severely with powdery mildew on both cotyledon and true leaves, followed by R1 type. On the other hand, R2 type showed slight or no symptom on those.

The second test(September): R1 type was infected with powdery mildew on cotyledon. Most of S type and R2 type showed slight or no symptom on it. In true leaves, S type and R1 type was infected severely with powdery mildew derived from melon, but most of R2 type showed resistance to it. When powdery mildew derived from watermelon inoculated on a true leaf, the varietal differences of resistance showed similar ones as it done from melon.

These results suggest that the new line of powdery mildew may appear in Japan.



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800 (PS 10)

**GENETIC VARIABILITY FOR EATING QUALITY ATTRIBUTES IN SWEET CORN.**

F. Azanza* and J.A. Juvik, Department of Horticulture, University of Illinois, Urbana, IL 61801.

Some of the primary physiological attributes of sweet corn eating quality that have previously been associated with consumer preference are kernel moisture content, pericarp tenderness (the force required to puncture the pericarp), sugar content and the concentration of phytoglycogen, a water soluble starch, and dimethyl sulfide (DMS), a volatile aromatic compound. This experiment was conducted to evaluate a set of 24 sweet corn inbreds with three endosperm mutations (4 *sugary1*, 7 *sugary enhancer*, and 13 *shrunken2*) for variation for these characteristics over two years on fresh ears harvested at 18 and 22 days after pollination (DAP). Significant genotypic variability was observed among inbreds, as well as between harvest stages for all the characteristics. Kernel moisture ranged from 69 to 79%, pericarp tenderness from 49 to 165 g/mm2, sugar content from 125 to 496 mg/g, phytoglycogen from 4 to 212 mg/g and DMS from 4 to 65 µg/g of dry matter at 18 DAP. From 18 to 22 DAP ears, averaged over the inbreds, were found to decrease 7% in kernel moisture, 25% in tenderness, 17% in sugar and 40% in DMS content, and increase 32% in phytoglycogen. Genetic differences among the inbreds accounted for most of the total variability for the attributes analyzed. This suggests that development of genotypes with improved eating quality can be accomplished.

801 (PS 10)

GENOTYPIC VARIATION IN COMMON BEAN IN RESPONSE TO COLD TEMPERATURE STRESS

Haytham Z. Zaiter*, E. Baydoun and M. Sayed - Hallak, American University of Beirut, c/o 850 Third Avenue, New York, N.Y., 10022.

Beans (Phaseolus vulgaris) are regarded as a susceptible crop to suboptimal temperatures. In temperate regions of the world, low temperature is a limiting factor for bean production at establishment when beans are planted early during the growing season to maximize the use of the available growing period. An experiment was carried out to test the germination response of 14 different cultivar/lines under 4 constant (8, 10, 12, or 18C) and 3 alternating suboptimal temperatures (10/8, 12/8, or 18/8C) in petri dishes. Phenotypes that germinated best at 8C were 'Volare', 'Great Northern (G.N.) Tara', 'G.N. Belneb #1', 'G.N. Spinel' and 'San Cristobal'. Germination of 'Pinto-UI-111' and 'Canadian Wonder' increased greatly when temperatures were increased by 2 to 4C for 2hr per 24hr, compared to a constant 8C, whereas, germination of 'G.N. Spinel' and "G.N. Belneb #1' was reduced. This revealed that alternating low temperature identified additional cold-tolerant phenotypes, which may be a more suitable technique for selecting germplasm with satisfactory germination at low temperature for use in the Mediterranean region. Tetrazolium tests showed variation in seed viability of the nongerminated seeds when imbibed at suboptimal temperatures for 14 days among bean phenotypes. Indicating the importance of including a viability test in future screening for cold-tolerant cultivars to select genotypes with seeds that remain viable until the germination medium is warm enough and does not rot and die at suboptimal temperature.

802 (PS 10)

NON-DESTRUCTIVE SCREENING FOR RESISTANCE TO MULTIPLE DISEASES USING EXCISED PLANT PARTS IN PEPPER (*CAPSICUM* SPECIES)

Do-Ham Pae* and Jin-Young Yoon, *Horticultural Experiment Station, 540 Tap-Dong, Suwon 441-440, Republic of Korea*
Jung-Myung Lee, *Dept. of Horticulture, College of Industry, Kyung Hee University, Young In, Kyunggi-Do 449-701, Republic of Korea*

A non-destructive screening system for resistance to multiple diseases was devised by utilization of excised plant parts such as leaf, shoot and fruit, which would allow evaluation of the same tested plants for reaction to major diseases and for other horticultural traits as well. A simple device made it possible to maintain freshness of the excised leaves and shoots long enough for the symptoms to develop fully. By inoculating suspension of bacterial leaf spot disease to the leaves excised, three genetic reactions, i.e, vertical resistance, horizontal resistance and susceptibility, were discerned as successfully as when inoculated on the intact leaves. 'CM331' and 'PI201234', of which resistance to *Phytophthora* blight had been shown in conventional screening by drenching at the seedling stage, also revealed the resistance when the inoculation was directly given to the excised shoot. Inoculation of anthracnose by high pressure spray resulted in more distinct differences between genotypes and less variation within genotypes than the conventional method by pins. Local lesions were observed in 6 days after inoculation of TMV on both excised and those kept intact on the plant in the resistant varieties. It was confirmed that excision of the plant parts for the disease screening by the new method gives little influence on the growth and yield of the plants being tested.

803 (PS 10)

A NEW PURPLE HULL PEA

T.E. Morelock*, D. Motes, Department of Horticulture and Forestry, D.R. Davis, Department of Food Science, University of Arkansas, Fayetteville, AR 72701

Southernpeas Vigna unguiculata are a popular crop in the southeastern U.S. They are grown in home gardens, as a fresh market vegetable and are an important processing crop to both canners and freezers. While several types of southernpeas are grown, pinkeye purple hull types are by far the most important type for processing. The breeding line Arkansas 87-435 is bush, early maturing, concentrated set pinkeye purple hull type that has been widely tested in the southeastern U.S. It was entered in the southern cooperative trial for 3 yrs. and has been evaluated by major processors in the region. This line is being released to fill the need for an early maturing concentrated set pinkeye purple hull type that is adaptive to machine harvest and narrow row cultivar.

804 (PS 10)

FRUIT FIRMNESS OF PARTHENOCARPIC VERSUS NONPARTHENOCARPIC PICKLING CUCUMBER CULTIVARS.

Kevin L. Cook*, August C. Gabert, and James R. Baggett, Department of Horticulture, Oregon State University, Corvallis, OR 97331-2911

Parthenocarpic pickling cucumbers may be advantageous to conventional nonparthenocarpic cultivars due to their higher fruiting capacity and ability to produce fruit under poor pollination conditions. The processing quality, particularly firmness, of parthenocarpic pickling cucumbers has been questionable. Fruit firmness of six parthenocarpic and six nonparthenocarpic cultivars was evaluated in 1992 at Brooks, Oregon. Plots covered with floating row covers, to prevent pollination and ensure parthenocarpic fruit set, were compared with noncovered plots. Parthenocarpic cultivars were significantly softer than nonparthenocarpic cultivars. Cultivars within the parthenocarpic and nonparthenocarpic types were significantly different from one another. Fruit produced under row covers were significantly firmer than those which were pollinated. Cultivars which were firmer under the row cover tended to be firmer in the absence of row cover. Floating row covers allow firmness and parthenocarpic fruiting ability to be evaluated concurrently.

805 (PS 10)

POLLEN VIABILITY AND FRUIT SET OF HEAT-TOLERANT AND -SENSITIVE TOMATO GENOTYPES UNDER OPTIMUM AND HIGH TEMPERATURE REGIMES

Aref Abdul-Baki* and John R. Stommel, USDA-ARS, Vegetable Laboratory, Beltsville, MD 20705-2350

Heat-tolerant and heat-sensitive tomato (*Lycopersicon esculentum* Mill.) genotypes were grown in the greenhouse under optimum and high temperature stress regimes. Levels of heat tolerance in the genotypes were established by determining percent fruit set under the high temperature regime. Under optimum temperature, fruit set in the heat-sensitive genotypes ranged from 41 to 54% and in the heat-tolerant genotypes from 45 to 91%. Under high temperature, no fruit set was observed in the heat-sensitive genotypes whereas, fruit set in the heat-tolerant genotypes ranged from 5 to 64%. In vitro germination and pollen tube growth of pollen taken from genotypes grown under optimum temperature conditions were determined before and after subjecting the pollen to 45C for 1, 2, and 4 hours. Pollen viability of heat tolerant genotypes was less affected by heat treatment than that of most heat sensitive genotypes. The results suggest that environmental factors independent of temperature may also influence pollen viability.

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806 (PS 10)

EVALUATION OF PAKISTANI APRICOT GERMPLASM FOR POTENTIAL AS BREEDING MATERIAL OR CULTIVARS IN THE CENTRAL SAN JOAQUIN VALLEY

Craig A. Ledbetter* and Lorenzo Burgos, Agricultural Research Service, Horticultural Crops Research Laboratory, 2021 S. Peach Ave., Fresno, CA 93727-5951

*Prunus armeniaca* L. germplasm, collected in Pakistan during 1988, is being evaluated for important horticultural characteristics. The study involves trees from 33 open-pollinated families planted at the Horticultural Crops Research Laboratory in Fresno, CA. Flowering season and fruit ripe dates for individual trees and families are being recorded. Important fruit characteristics measured include: fruit size and shape, skin over-color, total soluble solids and flesh pressure, fruit yield and eating quality. Evaluations of commercial apricot cultivars have been included as a source of comparison.

807 (PS 10)

ANATOMY OF BLIND NODES IN PEACH

Unaroj Boonprakob*, David H. Byrne[1], Robert E. Rouse[2] and Dale M.J. Mueller[3], [1]Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133, [2]Southwest Florida Research and Extension Center, IFAS, University of Florida, P.O. Drawer 5127, Immokalee, FL 33934, [3]Department of Botany, Texas A&M University, College Station, TX 77843-3258

Blind nodes in peach is widely observed in the mid summer growth in the southern of the U.S.A. This condition is characterized by the apparent absence of axillary buds. The developmental anatomy of blind nodes was investigated by sampling peach shoots every two weeks throughout the season. Although the bud initiation was observed in both blind and normal nodes, the differentiation in the blind nodes was limited such that no prophyll development was observed. Furthermore, it appeared that the initiated meristems in the blind nodes may have degenerated to form blank leaf axils.

808 (PS 10)

A PROCEDURE FOR OBTAINING ADDITIONAL REPULSION PHASE LINKAGE INFORMATION IN F2 FAMILIES

Jose Chaparro, Dennis Werner*, Barbara Crane, Dave O'Malley, Ronald Sederoff, Departments of Horticulture and Forestry, North Carolina State University, Raleigh, NC 27695-7609

F2 families provide less linkage information than testcross families for markers in repulsion phase orientation. However, generation of testcross families is often more difficult than the generation of F2 families in self-pollinating species. A procedure was developed for determining map position for markers within repulsion phase linkage groups generated in F2 families of peach. A genomic map consisting of homolog specific linkage groups of RAPD markers was generated in an F2 family obtained from NC 174RL x 'Pillar'. Numerous markers were identified that mapped to either allele of the *Gr* (red leaf) locus. The relative position of markers in these homolog specific groups was determined by characterizing the segregation distortion of the repulsion phase RAPD markers in a sample of 96 progeny homozygous recessive *grgr*. Repulsion phase markers within 20cM of *gr* deviated from a 3:1 segregation ratio. Individuals homozygous recessive for both *gr* and repulsion phase markers were then genotyped for coupling phase RAPD markers to facilitate generation of a graphical genotype. This graphical genotype information was used to determine orientation of the homolog specific linkage groups and to determine map order within the repulsion phase linkage group.

809 (PS 10)

**INHERITANCE AND RELIABILITY OF RAPD MARKERS IN MAPPING AND GENETIC DISTANCE STUDIES IN PEACH**

**M.R. Pooler* and R. Scorza, USDA, ARS, Appalachian Fruit Research Station, 45 Wiltshire Rd, Kearneysville, WV 25430**

**Because of the sensitive nature of the RAPD-PCR procedure, it has often been difficult to assess the inheritance of RAPD markers for mapping or genetic distance studies. Genetic analysis of RAPDs can be further complicated by the fact that markers are transmitted in a dominant fashion. Using six doubled haploid and therefore completely homozygous peach parental lines and seven $F_1$ populations resulting from crosses of these parents, we found that some RAPD markers did not follow expected inheritance patterns. Specifically, bands present in parents were not transmitted to the progeny. This phenomenon occurred in approximately 5% of the parent/progeny and primers tested. Although it is not clear whether these patterns are the result of as yet unexplained maternal or somatic effects in the peach or artifacts of the RAPD-PCR process, these results indicate that RAPD markers should be used cautiously in peach mapping and genetic diversity studies.**

810 (PS 10)

ELISA FOR SCREENING HAZELNUT SEEDLINGS FOR RESISTANCE TO EASTERN FILBERT BLIGHT

Clarice J. Coyne*, Richard O. Hamptom, John N. Pinkerton, Kenneth B. Johnson, and Shawn A. Mehlenbacher, Dept. of Horticulture, USDA-ARS, Dept. of Botany and Plant Pathology and Hort. Crops Lab., Oregon State University, Corvallis, OR 97331

Eastern filbert blight is a serious threat to hazelnut (*Corylus avellana)* production in the Pacific NW. Susceptible genotypes inoculated with the causal fungus, *Anisogramma anomala*, require 16 to 28 months of incubation to develop symptoms. A rapid and accurate screening system was needed to identify resistant genotypes in the OSU hazelnut breeding program, particularly in progenies segregating 1:1 for a single dominant resistance gene from the variety 'Gasaway'. An indirect enzyme-linked immunosorbant assay (ELISA) system was developed using polyclonal antibodies obtained by injecting New Zealand rabbits with antigens from pure cultures of *A. anomala*. The antiserum produced a positive reaction to the fungus in 1000-fold dilutions of the extracts from infected hazelnut tissue but did not react to 10-fold dilutions of healthy tissue in indirect ELISA.

811 (PS 10)

EVALUATION OF CHINESE RASPBERRY SPECIES IN NORTH CAROLINA

James R. Ballington*, Horticultural Science Department, N. C. State University, Raleigh, NC 27695-7609

Three raspberry species, Rubus corchorifolius, R. hirsutus, and R. innominatus, from southern China were evaluated for plant and fruit characteristics at Jackson Springs, N.C., in 1991 and 1992. Plants of all three species were well adapted and could potentially become naturalized if birds or mammals develop a taste for the fruit. Rubus corchorifolius stems were fully erect and primocanes were often 2.5 m tall by June 1, 1992. Rubus hirsutus produced profuse shoots covering up to 2 $m^2$ during the first growing season. Stems were fully erect and generally 0.2-0.3 m. tall. Rubus innominatus was very vigorous with an arching growth habit similar to black raspberry. Rubus corchorifolius bloomed in February and produced very little fruit. Berries were small and yellow with a distinctive sweet and sour flavor. Rubus hirsutus bloomed in early April in 1991 and February in 1992. Fruits were generally large, bright red, with a resinous aftertaste. Rubus innominatus bloomed in late April in 1991 and May in 1992. Fruits occurred in large clusters, were red to reddish-black, medium to large in size, and similar to R. parvifolius in quality. Rubus innominatus appeared very promising as a parent in raspberry improvement for the southeastern US.

812 (PS 10)

LEAF DISK SCREENING FOR RESISTANCE TO BOTRYTIS CINEREA IN STRAWBERRY GERMPLASM

Brenda Olcott-Reid*, Krista Kugler, and James N. Moore, Dept. of Horticulture and Forestry, University of Arkansas, Fayetteville, AR 72701

Several methods using detached leaf tissues were investigated as potential early screening techniques for identifying strawberry germplasm resistant to Botrytis cinerea, which causes gray mold fruit rot. The fungus penetrates young leaves, remaining latent and symptomless under the cuticle until the leaves die, when the pathogen resumes growth and sporulates, providing almost all the primary inoculum for fruit infections. The best leaf screening method involved spraying potted strawberry plants in a 20±5 C greenhouse with a suspension of B. cinerea conidia, enclosing the plants in a plastic tent with a humidifier to provide humidity >95% for 72 hours, then resuming normal greenhouse conditions for several days before sampling young leaves. Leaf disks 1 cm in diameter were then cut, surface sterilized in 70% ethanol for 15 sec and 1% sodium hypoclorite for 2 min, dipped in paraquat herbicide (20 mg/l a.i.) to kill the tissues, rinsed twice in sterile water, and plated on water agar containing .01% streptomyacin to inhibit bacterial growth.



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Plates were incubated at 21±2 C under 12 hour daylengths for seven days, and incidence and density of B. cinerea conidiophores on the disks determined. Despite much variation between disks within genotypes, clear differences in susceptibility between genotypes emerged which often correlated well with field suscpetibility to gray mold fruit rot.

813 (PS 10)

UNIQUE ORGANIC ACID PARTITIONING OF RABBITEYE VERSUS HIGHBUSH BLUEBERRIES

Mark K. Ehlenfeldt* and Filmore I. Meredith, Rutgers Blueberry and Cranberry Research Center, Penn State Forest Road, Chatsworth, NJ 08019, and Richard B. Russell Agricultural Research Center, College Station Road, Athens, GA 30613.

The fruit of 6 highbush cultivars and 8 rabbiteye cultivars and selections were evaluated by HPLC for levels and partitioning of the commonly found organic acids, citric, malic, succinic, and quinic. The two cultivar groups possessed distinctive acid partitioning patterns which could unambiguously separate rabbiteye and highbush clones. Highbush material was characterized by high citric acid, with percentages averaging 75% (range 38 to 90%), and succinic acid the next most plentiful acid, averaging 17%. In contrast, rabbiteye cultivars averaged 10% citric acid, and no clone had more than 22%. Succinic acid and malic acid were found in greater quantities than in highbush, averaging 50% and 34% respectively. Analysis of the fruit of 7 albino highbush selections exhibited a profile similar to standard highbush material, but with citric acid reduced to an average of 50%, and the proportional increase in other acids distributed between succinic and quinic acids.

814 (PS 10)

THE USE OF LEAF DISKS TO SCREEN FOR DOWNY MILDEW RESISTANCE IN TABLE GRAPES

Maurus V. Brown*, James N. Moore, and Patrick Fenn, Departments of Horticulture and Forestry, and Plant Pathology, University of Arkansas, Fayetteville, AR 72701

Disks (18 mm in diameter) from young, fully-expanded leaves of susceptible and resistant germplasm were inoculated on the abaxial surface by spray or pipette with $2 \times 10^4$, $5 \times 10^4$, $1 \times 10^5$ sporangia per milliliter of distilled water. Disks were placed on filter paper bridges in plastic containers with tap water to maintain high relative humidity and incubated at 24 C with a 14-hour photoperiod. Disease ratings were made five days after inoculations and disks were cleared in lactophenol (100 C) for two to three hours, stained with lactophenol/cotton blue, and examined by light microscopy. Uncleared disks of resistant material showed no symptoms, and susceptible material showed a range of symptoms and sporulation. Hyphal growth was evident in infected tissue of susceptible plants, but little or no growth was observed in resistant material. Results indicate that leaf disks can be used to evaluate downy mildew resistance. Further investigations will determine efficacy of this technique for screening seedling populations for field resistance.

815 (PS 10)

AVAILABILITY AND HERITABILITY OF SALT TOLERANCE IN RABBITEYE BLUEBERRY

Creighton L. Gupton* and James M. Spiers, USDA-ARS Small fruit Research Station, Poplarville, MS 39470

To assess the variability and heritability of salt tolerance in current rabbiteye blueberry (Vaccinium ashei) germplasm, about 30 plants from each of 15 crosses involving 8 parents were grown in sand culture. All plants were fertilized five days per week with a solution containing essential micro-and macronutrients but having an excess (250 ppm) Na level. After nine weeks, each plant was rated for vigor and chlorosis, dry weights of roots and shoots were recorded, and Na content of the roots and leaves were determined. The regression of progeny means on mid-parent means for leaf Na content produced a regression coefficient of 0.30, an estimate of heritability. There appeared to be little variability for Na content in the leaves of this germplasm so the moderate level of heritability would not be expected to produce much change in leaf Na by selection. Furthermore, there was no correlation between leaf Na content and either plant weight or rating which would facilitate selection of plants with low salt content in the leaves. variability existed for plant response to excess Na (plant rating) but heritability of the plant rating was estimated to be zero.

816 (PS 11)

HEXAZINONE MOVEMENT IN BLUEBERRY SOILS IN MAINE

David E. Yarborough* and Klaus I.N. Jensen, Department of Plant, Soil and Environmental Sciences, University of Maine, Orono, ME, USA and Agriculture Canada Research Station, Kentville, NS, Canada

An experiment was established to compare open mineral soil, soil with bark mulch, soil with blueberry cover and tilled clones on hexazinone movement through the soil. Hexazinone was applied preemergence to a lowbush blueberry field at 2 kg/ha in the spring of 1990 and soil samples were taken at the time of application, one month, six months and one year after application at a depth of 0-5 cm, 5-15 cm and 15-25 cm. At the time of initial application, the mulched plots had twice the amount of hexazinone as the others. The hexazinone concentration after one month shows the concentration of hexazinone decreased with an increase in depth, with the open areas having the highest levels of hexazinone. It appears that the hexazinone has moved down through the soil column with the higher concentrations above and lower concentrations below. The data indicate that the hexazinone decreased rapidly in the first month, and then declined by about half over each 6 months thereafter. It appears that there is less hexazinone in the lower layers of the soil and that the open areas had the highest concentration at one month but the levels equal out over time.

817 (PS 11)

BORON AFFECTS LOWBUSH BLUEBERRY FRUIT SET AND YIELD

John M. Smagula, Department of Plant, Soil and Environmental Sciences, University of Maine, Orono, ME 04469-5722.

Five lowbush blueberry (*Vaccinium Angustifolium* Ait.) clones with leaf tissue boron levels below 20 ppm were selected in a commercial lowbush blueberry field in Washington County, Maine. Four 2.4 $M^2$ treatment plots established on each clone received a foliar spray of Solubor at 0, 200, 400 or 600 ppm boron in September. The terminal 3.8 cm of stem, sampled in November, had increased concentrations of boron with increasing rates of boron application. Boron sprays also increased boron leaf tissue concentrations in July of the crop year. Ten stems with four flower buds were tagged in each treatment plot to determine the effect of boron treatments on fruit set and berry size. Fruit set was the same for each bud, but the number of blossoms and fruit per bud was greater on buds below the terminal. Yield increased in response to boron application up to 400 ppm, due to increases in fruit set, berry number and berry size of three of the five clones.

818 (PS 11)

NURSERY SURVEY OF ERICOID MYCORRHIZAS IN BLUEBERRIES

M.L. Schroeder*, B.L. Goulart and K. Demchak, Department of Horticulture, The Pennsylvania State University, University Park, PA 16802

Current literature reports that commercially produced and cultivated highbush blueberry (*Vaccinium corymbosum*) are virtually non-mycorrhizal, while native populations of *Vaccinium* are highly infected with the ericoid fungal symbiont. To confirm this information, a nursery and grower survey was initiated in PA, MI, and NC. Percent infection was determined by presence/absence counts using a grid-line intersect method. Results from 5-plant samples of cultivars 'Jersey', 'Northland', 'Bluecrop', 'Blueray', and/or 'Berkeley' (all obtained from nursery sources) from which three root subsamples per plant were cleared and stained revealed that all plants were mycorrhizal. Infection rates ranged from an average of 9.4% for two year old plants to 55.5% on one year old plants. An inverse relationship occurred between rate of ammonium-N and infection rate. Data also indicated a significant difference in infection rate among cultivars with 'Northland' most highly infected and 'Berkeley' least. Plants propagated in woodchip/sand or peat/sand media developed ericoid mycorrhizas. Data from a current greenhouse experiment supports this observation. We are currently identifying the fungi involved in this symbiosis.

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819 (PS 11)

WATER USE EFFICIENCY OF FOUR GRAPEVINE VARIETIES UNDER MEXICAN DESSERT CONDITIONS.

Fabián Robles-Contreras, Adán Fimbres-Fontes, Gerardo Martínez-Díaz* and Raúl Leonel Grijalva-Contreras, INIFAP-CECAB. Apartado Postal 125, Caborca, Sonora, México. 83600.

The main limitant of crop production in the agricultural area of Caborca, Sonora, is water availability since evaporation is greater than rainfall (2250 and 200 mm/yr respectively). Under this conditions is important to make a rational use of this resourse. In order to determine water consumptive use and water efficiency of Thompson Seedless, Perlette, Carignane and Tinta Madeira several experiments were conducted in 1983, 1984 and 1985. In Thompson Seedless various crops coefficients were applied in three phenological strages and the other varieties were exposed to the some irrigation intensities. The water consumptive use was 57.8, 51.1, 59.7 and 59.7 cm for Thompson Seedless, Perlette, Carignane and Tinta Madeira respectively and the water use efficiency (kg/m$^3$ water/ha) was 4.31, 3.92, 3.52 and 3.01 for the some cultivars.

820 (PS 11)

TIMING AND CONCENTRATION OF GIBBERELLIC ACID APPLICATIONS FOR BERRY THINNING AND SIZING OF 'VANESSA' SEEDLESS GRAPES.

Thomas J. Zabadal[1] and Bruce P. Bordelon[2]*, [1]Michigan State University, Southwest Michigan Research and Extension Center, Benton Harbor, MI 49022 and [2]Purdue University, Department of Horticulture, West Lafayette, IN 47907.

Timing and concentration of GA applications were evaluated for berry thinning and sizing on 'Vanessa'. Mid-bloom applications at 0, 5, 10, 15, 20 and 30 ppm GA were tested for berry thinning. Post-bloom applications of 0, 25 and 50 ppm GA at 7, 12, 16 and 21 days past mid-bloom were tested for berry sizing. None of the mid-bloom (thinning) treatments significantly reduced the number of berries per cluster or cluster compactness. Mid-bloom applications at 15, 20 and 30 ppm GA significantly increased berry weight. Post-bloom (berry sizing) treatments significantly increased berry weight with each increase in GA concentration for each time of application. The number of berries per cluster was significantly increased by sizing sprays at 7 and 12 days, but not at 16 or 21 days past mid-bloom. Cluster weight was significantly increased by 25 and 50 ppm GA applied at 7, 12 and 16 days past mid-bloom. All post-bloom applications significantly reduced the number and weight of shot berries.

821 (PS 11)

EFFECTS OF TRELLIS FORM ON RADIATION INTERCEPTION WATER USE AND PHOTOSYNTHESIS IN GRAPEVINES

Manea H. Al-hazmi*, Alan N. Lakso and Steven S. Denning, Department of Horticultural Sciences, NY State Agricultural Experiment Station, Geneva, NY 14456 USA

Manipulating radiation interception by using horizontal and vertical trellis forms was tested for effects on water loss and photosynthesis on sunny days. Water loss from 15 potted Pinot Noir vines of each form was estimated by weighing the vines at two hour intervals during the day. Radiation interception for vines and gas exchange of individual exposed leaves was measured over the day to evaluate the leaf activity patterns in relation to exposure patterns. Similarly, diurnal whole vine photosynthesis measurements were taken by using clear plastic "balloon" whole vine chambers. The horizontal form had higher radiation interception than the vertical form during the day, resulting in higher water loss from the horizontal form. Under N-S orientation, the horizontal form showed a gradual decrease in exposed leaf and whole vine photosynthesis starting in late-morning while the vertical form had a more uniform pattern over the day. The long periods of leaf exposure of horizontal canopies appears to induce a photosynthetic decline that also reduces afternoon transpiration. Vertical forms have two populations of leaves that are exposed for shorter periods, thus less photosynthetic decline occurs. Vertical trellis forms may have potential for improving water use efficiencies in arid regions with high radiation.

822 (PS 11)

SEASONAL VARIATION IN THE ACTIVITY OF NITROGEN ASSIMILATION ENZYMES FROM STRAWBERRY ROOTS

Douglas D. Archbold, Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington, KY 40546-0091

Significant seasonal fluctuations in the soluble and insoluble reduced N pools of strawberry roots and crowns suggest seasonal alterations in the activities of the enzymes responsible for nitrogen assimilation. The activities of glutamine synthetase (GS), NADH- and ferredoxin-glutamate synthase (NADH- and Fd-GOGAT), and glutamate dehydrogenase (GDH) were assayed from extracts of 'Allstar' strawberry roots sampled at intervals over 12 months from matted row beds. GS activity was high during late winter and declined 16-fold by the summer and fall. Although Fd-GOGAT activity was not detected, NADH-GOGAT activity exhibited over 5-fold higher levels during bloom and fruiting than at other times of the year. GDH activity fluctuated over 8-fold during the year with the highest levels occurring during the spring growth flush and after bed renovation. The seasonal changes in enzyme activities corresponded to significant events in plant development and indicate involvement of these enzymes in N assimilation and cycling in strawberry.

823 (PS 11)

DEVELOPMENTAL AND CULTIVAR COMPARISONS OF LIPOXYGENASE/LYASE-DERIVED VOLATILE COMPOUNDS FROM STRAWBERRY FRUIT

D.D. Archbold and T.R. Hamilton-Kemp, Department of Horticulture and L.A., University of Kentucky, Lexington, KY 40546-0091

Volatile products of the lipoxygenase/lyase pathway have been implicated in plant pathogen resistance mechanisms. Volatile compounds produced by strawberry fruit were measured by capillary GC using a direct headspace sampling technique. No intact fruit, assayed at the green, white, and red-ripe stages, emitted detectable amounts of volatiles by this method. However, crushed or damaged fruit yielded a few volatiles in the 1 µg/L range. The major compounds detected were derived from the lipoxygenase/lyase pathway and had the correct retention times for hexanal, *c*-3-hexenal, and *t*-2-hexenal. Hexanal and *t*-2-hexenal were produced by crushed white and red-ripe fruit whereas crushed green fruit produced these compounds and *c*-3-hexenal. Crushed white fruit from four cultivars, selected for reported differences in *Botrytis cinerea* resistance, yielded approximately equal amounts of hexanal and *t*-2-hexenal. The results will be discussed with respect to the possible involvement of these volatile compounds in pathogen resistance of strawberry fruit.

824 (PS 11)

STRAWBERRY REGROWTH AFFECTED BY CROWN SIZE FOLLOWING EXPOSURE TO SUB-LETHAL FREEZING

Michele R. Warmund', Department of Horticulture, University of Missouri, Columbia, MO 65211

The effect of crown diameter on the regrowth of 'Earliglow' and 'Honeoye' strawberry (*Fragaria x ananassa* Duch.) plants was evaluated following exposure to sub-freezing temperatures. Large-diameter (12-14 mm) crowns of both cultivars had greater leaf number and dry weight than medium (9-11 mm) and small (6-8 mm) diameter crowns when plants were grown in the greenhouse after the freezing test. Large diameter crowns of both cultivars and medium-diameter crowns of 'Honeoye' plants produced greater root dry weight than those of small-diameter crowns. The number of days to bloom of the primary flower increased with exposure to lower temperatures only in the large-diameter crowns of 'Earliglow'. However, in small-diameter crowns of 'Honeoye', the time of bloom decreased with exposure to lower temperatures. The fruit weight of small- and large-diameter crowns of 'Earliglow' plants decreased linearly with exposure to lower temperatures. 'Honeoye' plants subjected to -7C and unfrozen control plants had similar fruit weight.

825 (PS 11)

PERFORMANCE OF SUMMER-PLANTED STRAWBERRIES IN FLORIDA

Craig K. Chandler, Earl E. Albregts, and James C. Sumler, Jr.

Agricultural Research and Education Center, IFAS, University of Florida, Dover, FL 33527

Cold-stored (frigo) plants of 'Irvine' and 'Seascape' and non-chilled plug plants of 'Sweet Charlie' and FL 87-123 were planted on August 31 on raised beds covered with white-on-black polyethylene mulch. Very little water was needed for establishment of these plants (compared to that which is normally needed for the establishment of foliated bareroot plants). 'Irvine' and 'Seascape' produced more runners and were later to initiate fruit production than 'Sweet Charlie' and FL 87-123. 'Sweet Charlie' and FL 87-123 started producing a small amount of marketable fruit in late October, while 'Irvine' and 'Seascape' did not produce any marketable fruit until mid and late January respectively.



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826 (PS 11)

**THE COMMON AND DIFFERENT RESPONSES OF DORMANT GRAPEVINE BUDS TO CHEMICALS FROM VARIOUS GROUPS.**

Gil Nir[1]* and Shimon Lavee[2]. [1]R & D Authority of the Jordan Valley. [2]Inst. of Horticulture, Volcani Center, Bet-Dagan, 50-250 Israel.

Several groups of chemicals were tested for their effect on grapevine bud dormancy. Single-node cuttings were treated with hydrogen cyanamide and several of its derivatives, the respiratory inhibitors DNOC and azide, the alcohols 2-chloro ethanol and ethanol alone or in combination with cyanamide, the peroxide $H_2O_2$, Various sulfhydryls, the heribicides 3-amino triazol and paraquat and two inhibitors of polyamine biosynthesis. Although in each of these groups were active dormancy breaking agents which could be related to defined pathways, it became clear that the activity of these chemicals is specific and only partialy dependent on the common chemical configuration. It seems that in most cases the degree of activity could be related to their relation with peroxide scavenging activity or level of oxidation in the bud tissue.

827 (PS 11)

**BUD FRUITFULLNESS OF VINEYARDS IN THE NORTHWEST OF MEXICO.**

Gerardo Martínez-Díaz*, Raúl Grijalva-Contreras and Fabián Robles-Contreras, INIFAP-CIFAPSON-CECAB. Apartado Postal 125, Caborca, Sonora, México. 83600.

In order to determine bud frutifullness of vineyards a survey was performed from 1990 to 1993 in Caborca, Son., Méx. Fruitfullness of Thompson Seedless vineyards for raisin and wine production was higher than 30% and those for table grape production was lower than 20%. Canes of table grape vineyards (T. Seedless) strongly affected by bud necrosis had a fruitfullness lower than 10% from "eye" 1 to 21 and higher than 20% from "eye" 25 to 37. Fruitfullness of Perlette and Flame Seedless usually varied from 50 to 90% even when some vineyards showed lower percentages. In all cases, bud analysis was performed in the primary dormant bud from each "eye".

828 (PS 11)

**DEVELOPMENTAL STAGES OF TABLE GRAPES IN NORTHERN MEXICO.**

Alfonso A. Gardea*, R. Mancilla, R. Obando, E. Madero, and K.F. Byerly. C.I.A.D., A.C. and I.N.I.F.A.P. Apdo. Postal 1735, Hermosillo, Sonora. 83000, México. CIAD/DTAOV/RC/93/12.

An ampelographic collection was introduced to Comarca Lagunera, México in 1968. This work presents seven-year data of phenological evaluations on Cardinal, Queen, and Ribier mature vines, which are representatives of early, mid-, and late harvest seasons, respectively. Variables evaluated were the intervals required for a) budbreak (start to end), b) final budbreak to 50% bloom, c) 50% bloom to 50% vérasion, d) budbreak to vérasion, and e) soluble solids accumulation (SSA) after vérasion during the last two seasons. No significant differences were found for a), with averages around 213 Heat Units (HU, base temperature 10C). No differences were found either for b), with means close to 212 HU. However, differences ($p \leq 0.001$) were found for the interval bloom to vérasion with HU values for Cardinal, 720±32; Queen, 989±63; and Ribier, 1012±43. This interval accounted for the differences found in the whole cycle budbreak-vérasion. In the two-year study on SSA no differences in rates were found within genotypes, but among them. Therefore, our results suggest that -mainly- the bloom-vérasion period is responsible for defining the harvest season, along with budbreak timing and ripening rate.

829 (PS 11)

N, CA, AND MG FERTILIZATION AFFECTS GROWTH AND LEAF ELEMENTAL CONTENT OF 'DORMANRED' RASPBERRY

James M. Spiers*, USDA-ARS Small Fruit Research Station, Poplarville, MS 39470

'Dormanred' raspberry (Rubus species) plants grown in sand culture were subjected to varying concentrations of N, Ca and Mg over a two-year period. Increasing nitrogen fertilization resulted in linear reductions in leaf Ca, K, Zn, Fe, and Mn, but did not affect leaf Mg. Leaf Ca and K increased linearly with Ca fertilization, but applied Ca had an antagonistic influence on leaf Mg. Magnesium fertilization had a positive influence on leaf Mg but negatively affected leaf K, Ca and Mn. Plant growth was negatively correlated with Ca fertilization, leaf Ca, and leaf K, but had a positive correlation with leaf Mg and Mn. Nitrogen fertilization increased plant growth up to the mid-level of applied N, but additional N reduced plant growth.

830 (PS 11)

WATER POTENTIAL AND CELL TURGOR OF STRAWBERRY FRUIT ARE INFLUENCED BY RIPENING.

Kirk W. Pomper* and Patrick J. Breen, Oregon State Univ., Dept. of Horticulture, 4017 Ag and Life Sciences, Corvallis, OR 97331

Since large ripe strawberry fruit lose water faster than smaller unripe fruit, ripening fruit may out-compete unripe fruit for water within an inflorescence and thereby reduce yields. Xylem water potential ($\psi_w$) of greenhouse-grown 'Brighton' fruit, at different stages of development, was measured with a pressure chamber during mid-afternoon. Large ripe and medium sized green-white fruit within an inflorescence had a more negative $\psi_w$ than small green fruit. This suggests that small green fruit have a lower priority for xylem water moving into a strawberry inflorescence. Large ripe and small green fruit within an inflorescence had positive cell turgor (about 300 KPa), whereas turgor of medium sized green-white fruit was near zero, suggesting that these latter fruit were encountering greater water stress. When competing fruit on an inflorescence were removed, the calculated cell turgor was very similar to fruit with competition. Cell turgor of strawberry fruit is greatly influenced by developmental stage; this may moderate effects caused by water loss from neighboring fruit on an inflorescence.

831 (PS 11)

INFLUENCE OF MYCORRHIZA ON GROWTH OF STRAWBERRY SEEDLINGS

Amal P. deSilva* and W. Keith Patterson, Department of Horticulture and Forestry, University of Arkansas, Fayetteville, AR 72701

A green house experiment was conducted to study growth response of strawberry seedlings inoculation to mycorrhizal fungi. Seeds of strawberry cultivar 'sweetheart' were planted in trays of 25cm x 25cm x 5cm which were inoculated with Glomus intraradices. Spore densities of 0, 750, 1500, 3000, 7500, 12000 per plant were used. Results indicated that total dry wts. of plants inoculated with highest spore density significantly differed from the other treatments as well as from the controls. Moreover, total dry wts. of all treatments significantly differed from controls. The highest infection (71%) was seen at the 12000 spore density. Plant heights were variable at first two measurement dates. However, at the 3rd date, the 12000 spore density treatment significantly increased over all treatments except the 3000 level.

832 (PS 11)

**SURFACE COLOR AS A RIPENESS INDICATOR IN WILD, LOWBUSH BLUEBERRIES**

W. Kalt*, L.C. Hamilton, and M.D. Kee
Agriculture Canada Research Station,
Kentville, Nova Scotia, Canada B4N 1J5

Native lowbush blueberries are an important commercial crop in Atlantic Canada and the North Eastern United States. Wild stands, which are managed and harvested biennially, consist of many clones of Vaccinium angustifolium and V. myrtilloides. The commercial introduction of electronic color sorting of wild blueberries has prompted an examination of berry surface color in relation to sugar, acid and anthocyanin content of the fruit. Seven berries from each of 72 wild clones were measured individually for surface color (L,a,b), size (weight, diameter), and content of glucose and fructose, titratable acids and monomeric anthocyanins. Novel, microscale spectrophotometric methods were developed to conduct chemical analyses of individual berries. Correlations between surface color and other variates within and among clones were determined using multivariate statistics.



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833 (PS 11)

DEFOLIATION AND GIRDLING EFFECTS ON CHILLING ACCUMULATION IN RABBITEYE BLUEBERRY

Rebecca L. Darnell, Horticultural Sciences Department, University of Florida, Gainesville, FL 32611

Dormant two-year old 'Bonita' rabbiteye blueberries were subjected to the following treatments: 1) no defoliation, 2) one-half of the canes on a plant defoliated, and 3) complete defoliation. After 300 h at 7C, plants were brought into the greenhouse and vegetative budbreak was assessed. Completely defoliated plants exhibited rapid, extensive budbreak, averaging 70 budbreaks/plant. Plants or individual canes that retained their leaves during chilling averaged 25 budbreaks/plant. Budbreak on defoliated canes of partially defoliated plants (treatment 2) was drastically reduced compared to whole plant defoliation, averaging 30 budbreaks/plant. In a second study, plants were partially defoliated, as in treatment 2 above. The foliated canes remaining on each plant were then either girdled or non-girdled. After 300 h chilling, vegetative budbreak was assessed. Budbreak on defoliated canes of plants that had non-girdled foliated canes was low, averaging 15 budbreaks/plant. Budbreak on defoliated canes of plants that had girdled foliated canes was significantly higher, averaging 35 budbreaks/plant. These results suggest that chilling is inhibited by leaves, and this "inhibition" is phloem translocatable from leaves to buds on other canes, thus inhibiting budbreak on those canes.

834 (PS 11)

EFFECTS OF NITROGEN FORM ON VEGETATIVE GROWTH, PHOTOSYNTHESIS, AND EFFLUENT PH IN 'CLIMAX' AND 'SHARPBLUE' BLUEBERRIES

Donald J. Merhaut* and Rebecca L. Darnell, Department of Horticultural Sciences, IFAS, University of FL, Gainesville, FL 32611.

Effects of N form ($NH_4$ vs. $NO_3$) on growth, photosynthesis, chlorophyll concentration, and pH were evaluated in 'Climax' and 'Sharpblue' blueberries. Plants were fertilized every other day with a modified Hoagland's solution containing 5 mmoles N as $(NH_4)_2SO_4$ or $NaNO_3$. Change in solution pH as it percolated through the sand was measured. Effluent pH decreased to 3.0 for $NH_4$ treatments and increased to 5.7 for $NO_3$ treatments. As effluent pH changed, solution pH was adjusted to 6.5 for $NH_4$ treatments and decreased to 3.0 for $NO_3$ treatments, to maintain a comparable pH gradient within the sand. Leaf dry weight and total stem length were greater in $NH_4$ vs. $NO_3$ fertilized plants for both cultivars. Leaf area was significantly greater in the $NH_4$ vs. $NO_3$ treatments of 'Climax'. Nitrogen form did not affect stem or root dry weight in either cultivar. There were no differences in leaf photosynthetic rate or chlorophyll concentration between N treatments. Thus, increased growth in $NH_4$ treatments was not attributed to N form effects on photosynthetic rates.

835 (PS 11)

EARLY SHADING REDUCES FRUIT SET IN CRANBERRY

T.R. Roper*, J.S. Klueh, and M. Hagidimitriou, Department of Horticulture, University of Wisconsin, Madison, WI 53706-1590

Fruit set has been shown to be a major limitation of yield in cranberry (*Vaccinium macrocarpon*). Availability of resources has been implicated to limit fruit set. To determine when carbohydrate availability was most important to fruit set, we shaded 0.5 $m^2$ sections of a cranberry bed with shade cloth providing either 72% or 93% shade at prebloom, postbloom or preharvest in 1991 and 1992. Plots were not shaded during bloom to not interfere with pollination. Preharvest shading was never different than controls. Severe prebloom shading reduced fruit set in 1991, but not 1992. Severe postbloom shading reduced fruit set in 1991 and severe or light postbloom shading reduced fruit set in 1992. Postbloom shading reduced berry size and yield per subplot both years. Fruit set was determined in 1992 for plots that were shaded in 1991. Fruit set in 1992 was not affected by 1991 shading treatments. At the conclusion of the shading treatments, nonstructural carbohydrate content of uprights was reduced by 40 to 50% compared to controls. Fruit set appears to be dependent on resources produced during the postbloom period. These data support the hypothesis that fruit set in cranberry is resource limited.

836 (PS 12)

INVERTASE IN FLOWER BUDS AND MATURE FLOWERS OF SNAPDRAGON

Ricardo Campos* and William B. Miller, Department of Horticulture, Clemson University, Clemson, SC 29634-0375.

Invertase (EC 3.2.1.26) is an important enzyme in carbohydrate metabolism. This sucrose hydrolyzing enzyme was extracted and partially purified from mature flowers stored at -75° C, and fresh flower buds of snapdragon (*Anthirrinum majus* L.). Purification steps were precipitation with ammonium sulfate (25% to 80%) and two column chromatography fractionations: DEAE-Sephacel followed by Sephacryl S-200. An acid invertase was found in flowers of 'Maryland White' and also in flower buds of 'Potomac White'. Maximum enzyme activity was obtained at 55° C and a pH range from 4.2 to 5.0 for both enzymes in flowers and flower buds. Compared to citrate, acetate, citrate phosphate, and succinate buffers at pH 4.6 and 0.1 M increased enzyme activity by two fold.

837 (PS 12)

FLORAL INITIATION IN *RUDBECKIA HIRTA* UNDER LIMITED INDUCTIVE PHOTOPERIODIC TREATMENTS

Richard L. Harkess* and Robert E. Lyons, Dept. of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061-0327.

Two experiments were conducted to examine the response of *Rudbeckia hirta* to limited inductive photoperiodic treatments. Plants of *R. hirta* were grown to maturity under short days (SD). In the first experiment, mature plants were placed under LD for 0, 8, 16, 24 or 32 LD before being returned to SD with one group remaining under LD as a control. In the second experiment, mature plants remained under LD for 0, 4, 8, 12, 16, 20, 24, or 28 days before they were returned to SD. Meristems were sampled 0, 4, 8, or 12 days after return to SD and histologically examined. Plants receiving 32, 36, 40 or 44 LD were used as a continuous LD control. As the number of inductive cycles was increased, plant height and branch number increased. Plants receiving only 4 LD never progressed beyond floral initiation. After 8 LD, the meristems continued to develop even when returned to SD. Once involucral bract primordia initiated, the meristem was committed to flower whether in LD or SD conditions. Plants receiving 24 or more LD reached anthesis earlier than plants receiving fewer LD.

838 (PS 12)

SEQUENTIAL EFFECTS OF CARBOHYDRATE ACCUMULATION AND CONSUMPTION IN MARIGOLD SEEDLINGS

Guoqiang Hou* and Jack W. Buxton
Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington, KY 40546-0091

Supplemental $CO_2$ of 1500 $\mu l/l$ with radiation of 35 mols/day/$m^2$ resulted in a daily net accumulation of 60% increase in starch and 100% increase in soluble sugars at the end of the light period compared to seedlings grown at ambient $CO_2$. During low solar radiation periods the net daily accumulation of starch and soluble sugars was very little in seedlings grown with or without supplemental $CO_2$. At night, the concentration of starch decreased linearly with time, whereas soluble sugars decreased only slightly. The greater the concentration of carbohydrates at sunset the greater the metabolism of carbohydrates at night. When solar radiation was between 30-60 mols/day/$m^2$, the greater the concentration of starch in seedlings at the end of the dark period the lower the net daily accumulated starch at the end of the next day. Also higher night temperatures (23° vs. 8°), which maintained high metabolism of starch at night and thus a lower starch concentration at sunrise the next day, was correlated with greater net accumulated starch at the end of the next day. These results indicate that starch may inhibit photosynthesis in marigold seedlings; thus cultural practices that maintain low starch accumulation or high metabolism may enhance photosynthesis.

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839 (PS 12)

SUPPLEMENTAL IRRADIANCE DURING PRIMULA SEEDLING DEVELOPMENT

Meriam G. Karlsson* and Jan T. Hanscom, Department of Plant, Animal and Soil Sciences, University of Alaska Fairbanks, Fairbanks, AK 99775-0080

Seedlings of *Primula malacoides* Franch ' Prima Carmine Red' and *Primula vulgaris* Huds. ' Danova Lemon Yellow' received supplemental irradiance from high pressure sodium lamps for 2 weeks initiated at germination, 14 days after germination or 28 days after germination. The plants were grown at 15 ± 3C, 16 hours photoperiod and except during treatment, an average photosynthetic photon flux of 100 $\mu$mol· $s^{-1}m^{-2}$ (5.8 mol· $day^{-1}m^{-2}$). The irradiance levels during treatment were 200 or 300 $\mu$mol· $s^{-1}m^{-2}$ (11.5 or 17.3 mol· $day^{-1}m^{-2}$). There were no significant effects of supplemental irradiance on rate of flowering for *P. malacoides*, although the leaf number on the main shoot increased from 22 ± 4 leaves for control plants to 30 ± 3 leaves for plants receiving 300 $\mu$mol· $s^{-1}m^{-2}$. Flowering of *P. malacoides* averaged 100 ± 4 days from germination. Two weeks of 300 $\mu$mol· $s^{-1}m^{-2}$ initiated 4 weeks after germination resulted in an average plant dry weight of 0.56 ± 0.07 g compared to an average 0.39 ± 0.05 g for plants continuously grown at 100 $\mu$mol· $s^{-1}m^{-2}$.

840 (PS 12)

FLOWER INITIATION AND DEVELOPMENT OF PRIMULA GROWN AT INCREASED ROOT-ZONE TEMPERATURE

Meriam G. Karlsson* and Jan T. Hanscom, Department of Plant, Animal and Soil Sciences, University of Alaska Fairbanks, Fairbanks, AK 99775-0080

Plants of *Primula malacoides* Franch ' Prima Carmine Red' and *Primula vulgaris* Huds. ' Danova Lemon Yellow' were grown for 5 weeks after transplant in root growth chambers maintained at 16, 20 or 24C. Germination and seedling development occurred at 16C, 16 hours photoperiod and 5.8 mol· $day^{-1}m^{-2}$ (100 $\mu$mol· $s^{-1}m^{-2}$). The location for the root growth chambers and the continued plant development after the root temperature treatment was a greenhouse at 15 ± 3C and 16 hours at an average 5.8 mol· $day^{-1}m^{-2}$. Both flower initiation and flowering were first recorded for *P. malacoides* plants grown in the root growth chamber at 16C. The observed time from transplant to flower initiation was 28 days and to the first open flower 76 ± 5 days for the plants grown with 16C root zones. The number of leaves and shoots on *P. malacoides* plants showed an increasing nonsignificant trend with increasing root temperature. *P. vulgaris* may respond differently than *P. malacoides* to increased root temperature.

841 (PS 12)

THE CONTROL OF PRIMULA FLOWER INITIATION BY TEMPERATURE, PHOTOPERIOD, AND DAILY IRRADIANCE

Meriam G. Karlsson* and Jan T. Hanscom, Department of Plant, Animal and Soil Sciences, University of Alaska Fairbanks, Fairbanks, AK 99775-0080

The number of days required for flower initiation (FI) in *Primula vulgaris* Huds. ' Dania Lemon Yellow' was determined under growing conditions in the ranges of 8 to 20C, 8 to 14 hours photoperiod (PP) and 2 to 18 mol· $day^{-1}m^{-2}$ photosynthetic photon flux. Germination and early seedling development occurred at 16C, 11 hours PP and 10 mol· $day^{-1}m^{-2}$. The environment was changed four weeks after seeding to the experimental conditions and the study initiated. FI was defined to have occurred when the first change from a vegetative to a reproductive meristem was detected using scanning electron microscopy. The observed number of days from transplant to FI varied from an average 201 days at 8C, 8 hours PP and 2 mol· $day^{-1}m^{-2}$ to 28 days at 16C, 14 hours PP and 10 mol· $day^{-1}m^{-2}$. Based on the functional relationship developed to describe the interactions among temperature, PP and PPF, the optimum conditions within the studied ranges for fastest primula FI were 13C, 14 hour PP and 11 mol· $day^{-1}m^{-2}$.

842 (PS 12)

PRECONDITIONING PLUG-GROWN GERANIUMS WITH TEMPERATURE AND FERTILITY BEFORE STORAGE.

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

Seedlings of *Pelargonium* × *hortorum* 'Scarlet Elite' were grown to transplantable size in #406 plug trays. Seedlings were preconditioned for storage by applying 0, 75, 150 or 300 mg $l^{-1}$ nitrogen using a 15-16-17 fertilizer or growing the seedlings at 10, 15 or 20 C for 14 days immediately preceding storage. After preconditioning, seedlings were stored in the dark at 5 C for 0, 7, 14 or 21 days, and then transplanted to 10 cm pots and grown to flower under greenhouse conditions. Unstored seedlings flowered fastest when the highest fertility level was maintained during the preconditioning stage. However, fastest flowering of stored seedlings occurred when preconditioned with 150 mg $l^{-1}$ N. Plants preconditioned at the highest N level had the highest mortality rates during storage. Preconditioning seedlings at 10 or 15 C delayed flowering compared to seedlings grown at 20 C.

843 (PS 12)

COMPARATIVE STUDY OF TEMPERATURE INTEGRAL AND PFD ON VEGETATIVE GROWTH OF *EPIPREMNUM AUREUM* AND X *FATSHEDERA LIZEI*

C. Bruce Christie, Dept of Plant Science, Massey University, Palmerston North, New Zealand and Ian J. Warrington and C. Jill Stanley, The Horticulture and Food Research Institute of N.Z. Ltd, Palmerston North, New Zealand

The relationships between temperature and light on vegetative growth of the foliage house plants *Epipremnum aureum* (Linden and Andre) Bund. and X *Fatshedera lizei* (Guillaum) were investigated in a controlled environment study during the exponential growth phase. Responses were examined under conditions with a constant day temperature (30°C) in combination with constant night, split-night or sliding night temperatures with means of either 15° or 20°C. Two PFDs of 150 and 320 $\mu$mol-$s^{-1}$-$m^{-2}$ were included in each temperature treatment. Growth parameters (including dry matter increase, shoot elongation rate and leaf production rate) were all influenced by species but not by each temperature profile within the same temperature integral (ie all growth responses were directly related to mean night temperature). Growth rates were highest under the high PFD conditions but dry weight accumulation per unit of PFD was markedly higher at low PFD than at high PFD. The optimum temperature for vegetative growth of *Epipremnum aureum* was higher than that for X *Fatshedera lizei* and *Epipremnum aureum* was particularly sensitive to temperatures below 10°C.

844 (PS 12)

THE EFFECTS OF LONG DAYS AND SHORT DAYS ON GROWTH OF SEVERAL SPECIES OF HERBACEOUS PERENNIALS FOLLOWING VERNALIZATION OF PLUG-GROWN SEEDLINGS

Beth E. Engle*, Arthur C. Cameron and Royal D. Heins, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

*Achillea filipendulina* 'Cloth of Gold', *Astilbe arendsii*, *Campanula carpatica* 'Blue Clips', *Echinacea purpurea* 'Bravado', *Gaillardia grandiflora* 'Goblin', *Lavandula angustifolia* 'Munstead Dwarf', *Oenothera missouriensis*, *Rudbeckia fulgida* 'Goldstrum' plugs were stored at 5C for 0, 2, 4, 6, 8, and 10 weeks under a 5 $\mu$mol· $s^{-1}$· $m^{-2}$ PPF. Sample plants were removed and planted in 10 cm pots and placed in a 19C, constant temperature greenhouse under short-day or long-day photoperiods. Long-days were provided with night-break lighting from 10:00 p.m. until 2:00 a.m. by incandescent lamps. In *Achillea*, *Campanula* and *Gaillardia*, only terminal buds grew in the long-day photoperiod while both terminal and lateral buds grew under short-days. Development of *Astilbe*, *Echinacea*, *Oenothera*, *Rudbeckia* was minimal under short-days compared to that under long-days. *Lavandula* in the early treatments remained vegetative, short, and compact under short days, whereas plants elongated and flowered while grown under long days. Longer durations of storage shortened the time from potting to flowering for *Lavandula*.

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845 (PS 12)

**DEVELOPING A SIMPLE GRAPHICAL USER INTERFACE FOR USE WITH THE ROSESIM COMPUTER GROWTH MODEL**

Douglas A. Hopper*, Troy T. Meinke, and Virginia S. Story, Department of Horticulture, Colorado State University, Fort Collins, CO 80523

ROSESIM is a computer simulation model 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. ROSESIM may use average PPF and temperature values over the whole development time, or daily integrated values from actual greenhouse conditions may be read from a file in ASCII format. Using SAS, predictions from ROSESIM have been plotted with the actual recorded plant growth data to illustrate the accuracy of the model.

ROSESIM reads data from an ASCII file containing at least 3 columns of data (PPF, DT, and NT), and also outputs to an ASCII file that is accessible to many graphics packages. A graphical routine developed in C++ to run inside the Microsoft® Windows 3.0 or 3.1™ programming environment allows numerous options for plotting results. The Windows environment permits several plots to be presented simultaneously on the computer screen for ease of visual comparison and decision making.

846 (PS 12)

**LEAF, STEM, AND FLOWER CHARACTERISTICS OF *ROSA HYBRIDA* L. UNDER DIFFERENT $CO_2$ CONCENTRATIONS**

Troy T. Meinke*, Douglas A. Hopper, and Virginia S. Story, Department of Horticulture, Colorado State University, Fort Collins, CO 80523

Two greenhouses received ambient $CO_2$ and two were enriched between 1000 and 1200 ppm $CO_2$ when vents were closed. Two-year-old *Rosa hybrida* L. 'Royalty', 'Emblem', and 'Samantha' plants growing in each house were pinched 20 Oct. and 28 Dec. 1992 for Christmas and Valentine's Day crops. All temperature set points were 22C/17C day/night. At flowering, 5 shoots from each bench location were destructively sampled for stem diameter, stem length, and fresh and dry weights of stem, leaves, and flower bud.

At flowering for the Christmas 1992 crop, shoots in the enriched houses tended to have larger stem, leaf, and flower fresh weights, and larger stem diameters. Analysis of variance found stem lengths of combined cultivars to be longer ($p < .05$) in the $CO_2$ enriched houses. Mean stem lengths were 68.8 cm and 63.9 cm for flower stems in $CO_2$ enriched and ambient houses, respectively. Dry weight data from the Christmas crop, and results from the 1993 Valentine's crop will be presented.

847 (PS 12)

**FLOWERING COMPARISONS OF THREE POPULAR 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. Two greenhouses received ambient $CO_2$ and two were enriched to 1200 ppm $CO_2$ when vents were closed. All temperature set points were 22C/17C day/night. 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 weights of stem, leaves, and flower bud. Time to visible bud and to flowering from pinch also were recorded.

Analysis of variance for the 1992 Christmas crop did not find significant differences for flowering times, but trends in response were evident. The 3 cultivars had mean flowering times of: 'Royalty', 51.3 days; 'Emblem', 52.3 days; and 'Samantha', 54.0 days. Enrichment with $CO_2$ showed a trend for decreased average flowering times for all 3 cultivars. Results from the 1993 Valentine's Day crop will also be presented.

848 (PS 12)

**CORRELATION OF POINSETTIA GRAFT UNION DEVELOPMENT WITH TRANSMISSION OF THE FREE-BRANCHING AGENT**

Gerardo Ruiz-Sifre*[1], John M. Dole[1], Paul E. Richardson[2], Brian Kahn[1] and Joanna Ledford[2] [1]Dept. of Horticulture and Landscape Architecture and of [2]Botany, Oklahoma State University, Stillwater, OK 74078.

*Euphorbia pulcherrima* Willd. ex. Klotzsch 'Eckespoint C-1 Red' (C-1) a restricted-branching poinsettia and 'CB' a free-branching graft-hybrid were approach grafted. Graft unions were removed from poinsettia grafted pairs at 0, 5, 10, 15, 20, 25 or 30 days after grafting for anatomical study and the portion below the graft union was allowed to regrow. By 10 days after grafting, C-1 receivers showed increased branching and C-1 and CB parenchyma cells were actively dividing, producing new parenchyma cells (callus). Callus connected CB donors and C-1 receivers and may have allowed the transmission of the branching agent by 10 days after grafting. Parenchyma cells differentiated into nodules for the formation of new cambium by 25 days after grafting. CB donors and C-1 receivers were interconnected by new vascular tissue after 25 days of graft formation. CB donors may have controlled the differentiation of vascular tissue of the graft union.

849 (PS 12)

**INTERACTION BETWEEN SHIPPING AND ROOTING TEMPERATURE ON VERNALIZATION OF *LILIUM LONGIFLORUM* THUNB.**

John E. Erwin* and Gerard Engelen-Eigles, Department of Horticultural Science, University of Minnesota, St. Paul, Minnesota 55108.

*Lilium longiflorum* Thunb. cv 'Nellie White' bulbs (17.7-20.3 cm circumference) were received immediately after harvesting from the field. Bulbs were placed in moist sphagnum peat in plastic bags to simulate a shipping crate and were placed in controlled environment chambers maintained at 10, 20 or 30C for 2 wks. Bulbs were then planted in soilless medium in a 15.2 cm pot and were placed into controlled environment chambers maintained at 10, 20, or 30C for root development for 2 weeks to yield 9 different shipping/rooting treatments. Potted bulbs were then vernalized for 6 weeks at 6C. Bulbs were then placed in a glasshouse maintained at 18 ± 2C under natural daylight. Data were collected on date of emergence, visible bud, and anthesis. Leaf and flower number were also collected. Time to emergence and visible bud increased as the shipping temperature which bulbs were exposed to increased. Bulbs which were exposed to 10C shipping and/or rooting environment had reduced leaf and flower number. Exposure of bulbs to 30C during the shipping treatment resulted in plants which appeared undercooled and/or unvernalized.

850 (PS 12)

**TEMPERATURE, IRRADIANCE, AND COOLING TREATMENT LENGTH AFFECT *PELARGONIUM X DOMESTICUM* FLOWERING.**

John E. Erwin and Gerard Engelen-Eigles*, Department of Horticultural Science, University of Minnesota, St. Paul, Minnesota, 55108.

Rooted cuttings of *Pelargonium x domesticum* B. cv 'Vicki' were placed in controlled environment chambers maintained at 2, 6, 10 or 14C. Irradiance levels were 0, 200 or 350 $\mu$mol $s^{-1}$ $m^{-2}$. Plants were rotated among chambers at 0900 and 2100hr (12hr photoperiod) daily to yield 16 day/night temperature (DT/NT) treatments. Plants were removed from treatment chambers after 3, 4.5 or 6 weeks and were placed in a glasshouse maintained at 12 ± 2C. Data were collected at anthesis on node number from initiation of the cooling treatment to the base of the inflorescence, total flower number per plant and branch number. Node number increased exponentially from 16.1 to 22.3 as the average daily temperature which plants were cooled at increased from 2 to 14C. Total flower number per plant increased from 105 to 127 as NT increased from 2 to 10C. Flower number was unaffected by DT. Flower number per plant increased from 97 to 127 and node number decreased from 17.6 to 16.4 as irradiance levels increased from 0 to 350 $\mu$mol $s^{-1}$ $m^{-2}$. Flower and branch number increased as the length of the cooling treatment increased from 3 to 6 weeks. Node number was unaffected by the length of the cooling treatment.

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851 (PS 12)

GROWING TEMPERATURE OPTIMA OF FOUR ORNAMENTAL GRASSES

C.Lavis-Ham* and M.L. Albrecht, Dept. Hort., For., & Rec. Res., Waters Hall, Kansas State University, Manhattan KS 66506-4002

Growth chamber studies were conducted to determine the optimum temperature for growth of four ornamental grasses: *Imperata cylindrica* 'Red Baron', *Carex morrowii* 'Aurea Variegata', *Pennisetum alopecuroides* 'Hameln', and *Schizachyrium scoparium.* Plants were grown in chambers using temperatures of 15, 20, 25, and 30C. Measurements of fresh and dry shoot/root weights, tiller number, leaf area and plant height were taken after 10 weeks. *Schizachyrium* and *Imperata* exhibited an increase in growth as temperature increased, with 30C appearing to be the optimum for both species. *Pennisetum* showed positive gains in size and quality at 20 and 25C. *Carex* showed ideal growth at 20C.

In addition to the chamber study, measurement of chlorophyll fluorescence from intact leaves was used to identify temperature optima. Preliminary results suggest the fluorescence technique may not be conclusive when using species with low photosynthetic productivity.

852 (PS 12)

CELLULASE ACTIVITY IN COLEUS

Yalai Wang* and Lyle E. Craker, Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

The cellulase in leaf abscissing abscission zones of coleus was observed to have an isoelectric point of 4.7. Ethylene promoted activity whereas IAA inhibited activity in the abscission zones as compared with untreated controls. The enzyme could be purified 130 fold with a combination of gel filtration, and anion exchange and affinity chromatography. Both silver-stained SDS-PAGE and cellulase activity-stained native PAGE exhibited 2 bands in the finally purified protein, suggesting two isozymes. The 2 protein bands with molecular weights of 56 and 62 kD were apparently monomers. A test of cellulase activity at various pHs indicated high level of activity at pH 5 and pH 7.2. Activity increased with an increase in reaction temperature to 50°C. Both isozymes appeared necessary for abscission in coleus.

853 (PS 12)

DIFFERENTIATION OF INFLORESCENCES IN SEEDLINGS OF TWO CULTIVARS OF GERANIUM

Suzhen Yin*, Effin T. Graham, Terri W. Starman and Priyavadan A. Joshi Department of Ornamental Horticulture and Landscape Design, University of Tennessee, Knoxville, TN 37901-1071.

Histological samples were collected from 1st to 10th and 1st to 13th leaf stages (1 cm leaf size) from 'Multibloom Scarlet' and 'Red Elite' respectively. The tissues were fixed with formaldehyde-acetic acid-ethanol, embedded in paraffin, sectioned at 10 μm, and median longitudinal sections were stained with hematoxylin-Alcian blue. The earliest signal of inflorescence development was flattening of a meristematic structure which differentiated laterally adjacent to the apical meristem. This event had occurred by the 5th and 8th leaf stages in 'Multibloom Scarlet' and 'Red Elite' respectively. The results observed in paraffin sections were confirmed with stereomicroscopy and scanning electron microscopy.

854 (PS 12)

PREDICTION OF POINSETTIA CROP DEVELOPMENT

Patricia C. Branch*, E.N. O'Rourke, Jr. and P.W. Wilson, Dept. of Horticulture, Louisiana State University, Baton Rouge, LA 70803

Temperature is most often used to control the progress of a poinsettia (Euphorbia pulcherrima Willd.) crop after flower initiation, but lack of good temperature control can make crop timing difficult. Degree-day summations are used to monitor and predict developmental stages of many crops. The objective was to determine whether degree-days can be used to predict poinsettia crop development. Dates of occurrence of first bract color and anthesis were observed for 'Gutbier V-14 Glory' and 'Annette Hegg Dark Red' poinsettia plants for 3 years. Total degree-day accumulation was read from an electronic instrument each day dates were recorded. There was a high level of consistency in the degree-day values, suggesting that degree-day accumulations offer a means of monitoring crop progress and of calculating temperature regimes so that plants finish on time.

855 (PS 12)

INTERACTION BETWEEN IRRADIANCE AND PHOTOPERIOD ON *ANTIRRHINUM MAJUS* L. FLOWER INITIATION.

John E. Erwin and Debra J. Schwarze*, Department of Horticultural Science, University of Minnesota, St. Paul, Minnesota 55108.

*Antirrhinum majus* L. cv 'Winchester' seedlings (first true leaf stage) were placed in controlled environment chambers maintained at 20C under 8, 10, 12 or 14 hr photoperiods for flower induction. Seedlings were grown at irradiance levels of 240, 315, 380 or 460 $\mu$mol $s^{-1}$ $m^{-2}$ within each chamber. Plants were removed after 7, 14 or 21 days and were placed in a glasshouse maintained at 20 ± 2C under natural photoperiod and irradiance levels for flower development. Data were collected on flower number and number of nodes below the first flower when all flowers were visible on the inflorescence. Node number decreased from 67 to 43 nodes as photoperiod increased from 8 to 14 hrs. Increasing irradiance hastened flowering on plants grown under 8-12 hr photoperiods only and had no effect on flower number. Flower number increased from 23 to 30 as photoperiod length increased from 8 to 14 hrs. Node number decreased from 57 to 44 nodes and flower number increased from 22 to 31 flowers as the time of treatment increased from 7 to 21 days under the 14 hr photoperiod. Time of treatment had no effect on node number or flower number when plants were grown under 8 or 10 hr photoperiods.

856 (PS 12)

NIGHT TEMPERATURE, PPF, AND DURATION OF LONG DAY TREATMENT EFFECTS ON FLOWERING IN TWO GYPSOPHILA CULTIVARS

Peter R. Hicklenton*, Suzie M. Newman and Lindsay J. Davies, Agriculture Canada, Kentville, N.S. B4N 1J5 and Horticulture and Food Research Institute of New Zealand Ltd., Batchelar Research Centre, Private Bag 11 030, Palmerston North, New Zealand.

Winter greenhouse production of perennial baby's breath (*Gypsophila paniculata* L.) is hampered by short daylength, low PPF and low temperatures. Flowering of the popular cultivar 'Bristol Fairy'(BF) can be improved by supplemental assimilation lighting, but the costs are rarely justifiable. 'Bridal Veil' (BV) is a new cultivar with similar flower morphology to BF. BF and BV were grown under long day (LD) conditions at 8, 12, 16 and 20C night (20C day) and either 450 or 710 $\mu$mol $s^{-1}$ $m^{-2}$ in controlled environments. Most BF plants failed to flower at 8C in both PPF. Nearly all BV plants flowered irrespective of growth conditions. Flower yield decreased with night temperature in BF but was greatest at 8 or 12C in BV. BF required more LD cycles (>56) than BV for maximum stem elongation and flower yield. Termination of LD conditions before the start of inflorescence expansion resulted in reduced yields in all plants.

857 (PS 12)

PRODUCTIVITY OF FIELD-GROWN SPECIALTY CUT FLOWERS

Terri W. Starman*, Teresa A. Cerny and Sharon E. Millsaps, Department of Ornamental Horticulture & Landscape Design, University of Tennessee, Knoxville, TN 37901-1071

The objective was to determine the productivity and profitability of field-grown specialty cut flowers. Productivity and profitability of cut flowers were based on yield and stem length measurements. Two 54 $m^2$ beds were planted with 20 annual cut flower species and two beds with 20 perennial species. The experiment was a randomized complete block design with 16 plants per species in each block. Total number of flower stems per replication produced by annual species ranged from 35 to 1946. Percentage of productive plants was 100% for most of the annual species. The total number of flower stems harvested per productive plant ranged from 4 to 122 and bunches of flowers per 0.09 $m^2$ varied from less than 1 to 12. Income estimates per 0.09 $m^2$ indicated some species were highly profitable. Total number of flower stems per replication produced by perennial species ranged from 8 to 1501. Seven species of perennials did not bloom. The 3 perennial species with the greatest total number of flower stems



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harvested had 100% of the plants in production during the growing season and a greater total number of flower stems harvested per productive plant. Only four perennial species showed a positive income estimate per 0.09 m². Percent mortality had an effect on productivity and was greater overall for the perennial species than the annual species. The lower overhead associated with field production coupled with highly productive species proved to be profitable.

858 (PS 12)

USING COMPUTER SIMULATION TO UNDERSTAND CONTAINER MEDIA

Silvia Burés*, Franklin A. Pokorny, Alan M. Ferrenberg, David P. Landau, Department of Horticulture and Center for Simulational Physics, University of Georgia, Athens, Ga 30602-7273

Monte Carlo simulation has proven useful to understand container media properties. Although use of container media in horticulture is widespread, their physical properties are often misunderstood. Container media usually have larger external pores than natural soils, and the components from which they are formulated may have internal porosity that often accounts for half the total porosity. Traditional laboratory methods have provided limited insight into container media phenomena because of the difficulty in distinguishing between internal and external pores. By means of computer simulation we have characterized external porosity and pore size of container media. We have also been able to study volume shrinkage upon mixing components with different particle sizes. Pore size can be correlated with water retention characteristics, and size of external pores is related to the sizes of the particles that are mixed. With Monte Carlo simulation one can mix different particle sizes in different proportions, thus determining the relationships between pores and particle sizes.

859 (PS 12)

COMPETITIVE EFFECT OF TURFGRASS AISLES ON PRODUCTION AND QUALITY OF FIELD-GROWN ZINNIAS

Alan Stevens* and Karen Gast, Department of Horticulture, Forestry and Recreation Resources, Waters Hall, Kansas State University, Manhattan, KS 66506.

Field production of specialty cut flowers has become of increasing interest during the last few years. A production system consisting of permanent bed planting as opposed to planting as a single row crop is common. Aisle management is an important component of this system. A vegetative aisle cover affords product quality enhancement and improved labor and equipment utilization throughout the field. This study compared the competitive effect on zinnia yields and flower quality between bare ground and five turfgrass species planted in the aisles. Plots surrounded by bare ground had higher yields and better quality than the turfgrass plots. Annual ryegrass had the greatest competitive effect on flower production and quality of the five turfgrass species studied.

860 (PS 12)

RICE HULLS AS A VERMICULITE SUBSTITUTE IN PEAT-BASED MEDIA FOR GROWING GREENHOUSE BEDDING PLANTS

Shelly D. Dueitt*, J'Lynn Howell, and Steven E. Newman, Department of Horticulture, Mississippi Agricultural and Forestry Experiment Station, P.O. Drawer T, Mississippi State, MS 39762-5519

The objective of this study was to determine the feasibility of using rice hulls as a vermiculite substitute in sphagnum peat moss-based media for growing greenhouse bedding plants. Rice hulls are a by-product of the rice milling process, which is a major agricultural industry in Mississippi. Plugs of *Begonia semperflorens* 'Vodka', *Impatiens wallerana* 'Super Elfin Red', 'Super Elfin Red Velvet' and 'Blue Pearl', *Catharanthus roseus* 'Cooler Peppermint', and *Salvia splendens* 'Empire Lilac' were transplanted into 10 cm pots containing sphagnum peat moss-based media modified with either composted or fresh rice hulls and/or vermiculite. Vermiculite was substituted (by volume) as follows: 5 peat: 5 vermiculite: 0 rice hulls, 5 peat: 4 vermiculite: 1 rice hulls, 5 peat: 3 vermiculite: 2 rice hulls, 5 peat: 2 vermiculite: 3 hulls, 5 peat: 1 vermiculite: 4 rice hulls, and 5 peat: 0 vermiculite: 5 rice hulls. In general, plant growth in media containing composted rice hulls was equivalent or superior to the vermiculite controls.

861 (PS 12)

KENAF FIBER CORE AS A VERMICULITE SUBSTITUTE IN PEAT-BASED MEDIA FOR GROWING GREENHOUSE BEDDING PLANTS

J'Lynn Howell*, Shelly D. Dueitt, and Steven E. Newman, Department of Horticulture, Mississippi Agricultural and Forestry Experiment Station, P.O. Drawer T, Mississippi State, MS 39762-5519

The objective of this study was to determine the feasibility of using kenaf fiber core as a vermiculite substitute in sphagnum peat moss-based media for growing greenhouse plants. Fiber core is a by-product of kenaf, an alternative fiber crop, which is being evaluated in Mississippi. *Begonia semperflorens* 'Vodka', *Impatiens wallerana* 'Super Elfin Red', 'Super Elfin Red Velvet' and 'Blue Pearl', *Catharanthus roseus* 'Cooler Peppermint', and *Salvia splendens* 'Empire Lilac' were transplanted into 10 cm pots containing peat moss-based media modified with various forms of core and/or vermiculite. Finely ground or coarse core was used in fresh or composted form and charged or not charged with nitrogen. Core used as poultry litter and composted was also included. Vermiculite was substituted (by volume) as follows: 5 peat: 5 vermiculite: 0 kenaf, 5 peat: 4 vermiculite: 1 kenaf, 5 peat: 3 vermiculite: 2 kenaf, 5 peat: 2 vermiculite: 3 kenaf, 5 peat: 1 vermiculite: 4 kenaf, and 5 peat: 0 vermiculite: 5 kenaf. Plant growth was reduced as the volume of kenaf increased in the media.

862 (PS 12)

EFFECTS OF SUPPLEMENTAL LIGHTING AND PLANT DENSITY ON GROWTH AND DEVELOPMENT OF STOCK AND GODETIA

Serge Gagnon* and Blanche Dansereau, Centre de recherche en horticulture, Département de phytologie, Université Laval, Québec, Canada, G1K 7P4

Seeds of *Matthiola incana* 'Pink Appleblossom' and 'Miracle Crimson'(stock) and *Godetia Whitneyi* 'Grace Rose Pink'(godetia) were sown into 200 unit plug trays containing Pro-mix. Seedlings having 4 to 6 true leaves, were transplanted into ground beds containing a substrate composed of 40% sand, 45% loam soil and 15% peat moss (vol/vol). Stocks were planted at densities of 60 et 90 plants/m2 and godetias at 20, 30, 40 and 60 plants/m2. Plants were grown under ambient light conditions or a photosynthetic photon flux (PPF) of 60 $\mu mol\ m^{-2}s^{-1}$. After seedling stage, air temperatures were maintained at 18°C (day) and 13°C.(night). During the production cycles of fall-winter 1991 and 1992, a supplemental PPF reduced total production time by 26 et 27 days respectively. Supplemental light caused a reduction of stem length. Planting density did not effect the variables measured. With godetia, the supplemental light treatment significantly increased the number of saleable stems. Marketable yield increases were not proportional to higher planting densities.

863 (PS 12)

INHIBITION OF GROWTH OF CALADIUM BY HIGH TEMPERATURE

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

Caladium x hortulanum Birdsey 'Candidum' tubers were exposed to 26, 38, 43 and 48C for 1, 2 and 3 days. Tubers were then forced in a glass-glazed greenhouse. Tubers exposed to 48C for 1 and 2 days required significantly longer to emerge than all other temperature treatments, while tubers exposed to 48C for 3 days failed to emerge. After 4 weeks of growth, exposure of tubers to 43C for 2 and 3 days and 48C for all time periods resulted in plants with reduced shoot fresh weights and fewer leaves with a width greater than 15 cm. After roots developed to the edge of the pot and shoots emerged (10 days after potting), potted tubers were exposed to 43C for 0, 4, 8, 12, 16, 20 and 24 hours per day for 1, 3 and 5 days. Potted tubers exposed to 43C for 8 or more hours per day for 3 days and 12 hours or more for 5 days were significantly delayed in emergence. Only 33% of potted tubers exposed to 43C for 24 hours per day for 5 days emerged. Exposure to 43C for 1 and 3 days resulted in increased shoot fresh weights for exposures up to 12 hours per day. As the exposure time per day increased, shoot fresh weights decreased. Exposure of potted tubers to 43C for 16 hours or more per day for 3 days reduced plant height and the number of leaves with a width greater than 15cm. Regardless of the number of hours of exposure per day, potted tubers exposed to 43C for 5 days had reduced shoot fresh weights and fewer leaves with a width greater than 15cm as compared to unexposed potted tubers. As the number of hours of exposure per day increased, shoot fresh weight and the number of leaves with a width greater than 15cm decreased.



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864 (PS 13)

STORAGE STABILITY OF PARTIALLY PROCESSED CARROT SLICES, STICKS, AND SHREDS

Hidemi Izumi* and Alley E. Watada, Horticultural Crops Quality Laboratory, ARS, USDA, Beltsville, MD 20705-2350

Changes in quality of carrot slices, sticks, and shreds were investigated during storage at 0, 5 and 10C. The surface area per gram tissue was the greatest in shreds, followed by sticks and then slices. Weight loss showed a tendency to be greater in shreds than in slices or sticks at all temperatures. The microbial population from tissue surfaces increased on all cut forms with storage period; shreds contained the highest bacterial population, followed by sticks and slices at all temperatures. The texture of sticks, based on standard shear compression cell measurements, was greater than that of slices and shreds throughout storage at all temperatures. At 5 and 10C, the texture of slices was slightly greater than that of shreds. The surface color of all cut forms gradually faded during storage at all temperatures, although chroma value differed among cut forms. These results indicate that carrot shreds are more perishable than slices or sticks. However, we also observed that more Ca was absorbed by the shreds than by slices or sticks, so the quality of shreds may be regulated more effectively by various dip treatments.

865 (PS 13)

FURROW & DRIP IRRIGATION ON MUSKMELON FRUIT QUALITY

Gene E. Lester*[1], Norman Oebker[2] and Janice Coons[3], [1]USDA-ARS, Subtrop. Ag. Res. Lab., 2301 S. Inter. Blvd. Weslaco, TX 78596, [2]Plant Sci. Dept., U. of AZ, Tucson, AZ 85721, [3]Botany Dept., E. Ill. U., Charleston, IL 61920

Effect of furrow and drip irrigation 1-, 2-, or 4-days after all plots had been watered 8-days before harvest, on postharvest quality, was studied two years. Years had no effect nor was fruit firmness affected by water method or timing. Regardless of method, water 4-days before harvest produced fruit with significantly the lowest % sol. solids (10.8% vs. 12.2%), the greatest vol. (16.1 vs. 15.1 $cm^3X10^2$) and the greatest % moisture (88.5% vs. 87.4%) vs. no water after 8-days before harvest. Water 1- or 2-days before harvest produced fruit with variable quality differences vs. no water after 8-days. Drip watering 4-days before harvest vs. no water after 8-days, negatively affected sensory attributes with preference panelists rating lower for sweetness and overall fruit quality. Furrow watering produced fruit with inconclusive sensory ratings.

866 (PS 13)

INVERTASE INHIBITOR IN TOMATO FRUIT

Russell Pressey, R. B. Russell Agricultural Research Center, USDA, Agricultural Research Service, P.O. Box 5677, Athens, GA 30613

Tomatoes contain a high level of the enzyme invertase which hydrolyzes sucrose to glucose and fructose. A protein that inhibits invertase has been found in tomatoes, suggesting that it may be involved in the regulation of invertase activity. A procedure was developed for the separation of the inhibitor from invertase based on the higher stability of the inhibitor in acid solutions. Residual invertase in acid extracts of pericarp tissue was removed by anion exchange chromatography. The inhibitor has been purified to homogeneity by subsequent gel filtration and cation exchange chromatography. It is a heat-stable protein with a mol wt of 18,000. The reactivity of the inhibitor with tomato invertase is pH dependent with maximum inhibition at pH 4.7 and no inhibition at pH 3.5 and 6.2. The result is double pH optima for invertase activity in the presence of the inhibitor. The inhibitor is effective on invertase from potatoes and may be similar to the invertase inhibitor found in potatoes.

867 (PS 13)

QUALITY EVALUATIONS OF WATERMELON CULTIVARS

J. K. Collins[1], P. Perkins-Veazie[1], N. Maness[2], and B. Cartwright[3], [1]USDA-ARS, South Central Agricultural Research Laboratory, Lane, Oklahoma 74555; [2]Department of Horticulture, Oklahoma State Univ., Stillwater, OK 74078; [3]Department of Entomology, Wes Watkins Agricultural Research Extension Center, Lane, OK 74555.

The postharvest quality of one seedless and four seeded watermelon cultivars was studied. Melons were evaluated for ascorbic acid content, sugar composition, soluble solids concentration, lycopene concentration, color and sensory qualities. Ascorbic acid values were higher for 'Allsweet' and 'Jubilee' melons compared to the other cultivars. 'Black Diamond' had higher fructose levels than 'Calhoun Gray', 'Jubilee' or 'King of Hearts'. Soluble solids concentration was highest for 'Allsweet' and lowest for 'Black Diamond' melons. 'King of Hearts' fruit had the highest lycopene content which was correlated with chroma color values. Untrained taste panelists preferred 'Calhoun Gray', 'Jubilee', and 'Allsweet' for taste compared to 'Black Diamond' melons.

868 (PS 13)

INFLUENCE OF CLOMAZONE HERBICIDE ON POSTHARVEST QUALITY OF PROCESSING SQUASH AND PUMPKIN

L.A. Weston, M.M. Barth, R. Harmon* and H. Zhuang, Departments of Horticulture & Landscape Architecture and Nutrition and Food Science, University of Kentucky, Lexington, KY 40546.

Six processing squash and pumpkin cultivars (Marrow, Howden, Butternut, Buttercup, Golden Delicious, and Turk's Turban) were direct-seeded into replicated plots treated with selected pre-emergence herbicides. Treatments included application of varying rates of clomazone, an inhibitor of carotenoid biosynthesis. Problems associated with bleaching and whitening of fruit, and storability have been reported in squash and pumpkins treated with labelled rates of clomazone. Therefore, this study was initiated with FMC to evaluate herbicide treatment effects on cultivars during 6 wk postharvest storage. Replicated samples were stored at 18°C and quality was evaluated at each storage interval (0, 2, 4, 6 wk). Quality was assessed by total carotenoid and reduced ascorbic acid contents, color retention, peroxidase and lipoxygenase activities, % soluble solids, and fatty acid composition. Results indicated differences in levels of tissue bleaching, carotenoid contents, enzyme activities among cultivars over time. Treatment with high rates of clomazone resulted in reduced tissue carotenoid content, with certain cultivars more affected than others.

869 (PS 13)

BELL PEPPER INJURIES AND BACTERIAL SOFT ROT IN COMMERCIAL POSTHARVEST HANDLING SYSTEMS

Sergio J. Carballo, Sylvia M. Blankenship*, Douglas C. Sanders, David F. Ritchie[1] and Michael D. Boyette[2], Departments of Horticultural Science, [1]Plant Pathology and [2]Biological and Agricultural Engineering, Box 7609, North Carolina State University, Raleigh, NC 27695

Commercial postharvest handling systems were surveyed during two seasons to study handling methods on susceptibility of bell pepper fruit (*Capsicum annuum* L.) to bacterial soft rot (*Erwinia carotovora* subsp. *carotovora*). Fruit samples were taken from two field packers and one packing house in 1991 and two field packers and four packing houses in 1992. Numbers of injured fruits were classified as crushed, bruised, abraded or other. Fruits were inoculated with bacteria or left untreated then stored at 10 or 21° C. Fruit injury was less dependent on whether the operation was a packing house or a field packing line than on individual grower handling practices. In general, packing peppers in packing houses resulted in increased bruises while field packing increased abrasions. More open skin injuries, but not necessarily total injuries, resulted in more decay. In some situations, when chlorination was applied in packing lines, a reduction in rotted fruits from the field was observed.

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870 (PS 13)

POTATO CULTIVAR SUSCEPTIBILITY TO BLACKSPOT

Richard K. Peasah* & Cindy Tong, Department of Horticultural Science, University of Minnesota, St. Paul MN 55108

External bruising to potato tubers can result in a blue-black discoloration in the tuber flesh called potato blackspot (PBS). Three potato cultivars used in the Minnesota chipping industry (Atlantic, Frito Lay 1533, and Norchip) were tested for their susceptibility to PBS and compared to Russet Burbank. Tubers were bruised on the stem end using a spring-loaded bruiser and stored at 10°C from 1 to 3 days. PBS was evaluated 24, 48, and 72 hours after bruising. Percentage of bruised tubers showing PBS and Hunter L values of the bruised flesh were used to assess susceptibility. Percentage data showed that the order of most to least susceptible to PBS was Atlantic > Russet Burbank ≥ Frito Lay 1533 > Norchip. L values were not indicative of percentage of tubers showing PBS and may not be accurate measurements of susceptibility to PBS. Atlantic and Russet Burbank tubers were also bruised and stored at 25°C to determine whether a higher storage temperature affected PBS development. Atlantic tubers stored at 25°C showed less PBS than those stored at 10°C at each evaluation time. Russet Burbank tubers stored at 25°C exhibited less PBS than those at 10°C at 48 and 72 hr after bruising but not at 24 hr.

871 (PS 13)

EFFECTS OF CULTIVAR AND POSHARVEST TREATMENTS ON SOME QUALITY ATTRIBUTES OF ONIONS.

Judith Zambrano*, Hugo Ramirez and Juan Manzano, NURR, Univ. Los Andes, Trujillo, Posgrado Horticultura , UCLA, Barquisimeto, Venezuela.

Onions of cultivars 'Texas Grano 1025Y', 'Texas Grano 438', 'Hybrid Granex 429', and 'Red Burgundy' after curing, were stored at 5 °C, 90% RH for 1, 2, 3 and 4 weeks, then transfered to ambient temperature for 75 days. Total weight loss was measured every 2 weeks. Samples were taken to determine dry weight, reducing sugars and pungency. All the parameters measured were significantly affected by cultivar. 'Red Burgundy' had the highest dry weight (7.88 %) and greater pungency. 'Hybrid Granex 429' exhibited the lowest values for weight loss over the entire storage period and the highest reducing sugars content.

872 (PS 13)

MATURITY AND STORAGE EFFECTS ON POSTHARVEST ONION QUALITY

Marisa M. Wall and Joe N. Corgan, Department of Agronomy and Horticulture, New Mexico State University, Las Cruces, NM 88003

A two-year field study was conducted to evaluate the effects of maturity and storage on fresh market onion quality. Four short day onion cultivars (NuMex BR1, NuMex Sunlite, NuMex Starlite and Buffalo) were seeded in early October of both years. Bulbs were harvested at 5 different times, with harvest #1 when 20% of the bulbs in a plot had mature necks. The second harvest was when 80% of the bulbs in a plot had matured. Harvests #3, #4 and #5 were at 5, 10 or 15 days after the second harvest date. After curing, bulb firmness and weight, and the incidence of bulb diseases were evaluated for the 5 harvest dates. Bulbs were re-evaluated after 10 and 20 days storage in a shed under ambient conditions. Average bulb weight increased from 181.6g to 274.1g as harvest was delayed. Bulb firmness decreased from 56N to 52N. Percent diseased bulbs increased for all cultivars as harvest was delayed in 1991, while in 1992 this trend was not observed. In storage, average bulb weight and firmness decreased, while the incidence of bulb diseases increased greatly regardless of harvest date. Storage diseases were primarily *Aspergillus niger* and bacterial soft rot.

873 (PS 13)

DIFFUSIVITY OF WATER VAPORS IN POTATO TUBERS.

Theophanes Solomos, Aref A. Abdul-Baki, and James A. Bunce, Dept. of Horticulture, U. of MD., College Park, MD 20742, and Vegetable and Climate Stress Laboratories, USDA/ARS, PSI, Beltsville, Maryland 20705-2350.

It is known that, in a number of plant tissues, the diffusivity of water vapors is larger than that of $CO_2$. We have measured the water potential of both intact potato (*Solanum tuberosum*, cv. Russet Burbank) tubers, using a Wescor due point probe, and tissue slices, using the liquid exchange method. The water potential measured by both methods was similar. The results show that the diffusivity of water vapors is larger than that of $CO_2$. The difference in diffusivity between $CO_2$ and water vapors is attributed to a simultaneous loss of water through diffusion and surface evaporation. The results indicate that the contribution of the latter mechanism to water loss is more significant than simple diffusion.

874 (PS 13)

FIELD PERFORMANCE OF TRANSGENIC TOMATOES WITH REDUCED PECTIN METHYLESTERASE ACTIVITY

Denise M. Tieman*, Kurt D. Kausch, Delila M. Serra, and Avtar K. Handa, Department of Horticulture, Purdue University, West Lafayette, IN 47907-1165

We have introduced an antisense pectin methylesterase (PME) gene into Rutgers tomato to elucidate its role in fruit development and ripening. In greenhouse trials tomato fruits from transformant 37-81^ homozygous for the antisense PME gene ripened normally and contained higher levels of soluble solids than wild-type Rutgers fruits (Tieman *et al.* (1992) Plant Cell 4:667-679). Field trials of transgenic 37-81^ homozygous and azygous for the antisense PME gene and wild-type Rutgers were conducted during the summer of 1992. Field grown fruits from homozygous 37-81^ plants have significantly higher levels of soluble solids and total solids and a higher fruit pH than Rutgers or 37-81^ azygous fruits. Average fruit weight did not differ significantly in the three genotypes, but 37-81^ (homozygous) plants had a higher total fruit yield than Rutgers or 37-81^ azygous plants. Plant fresh and dry weights did not differ significantly among the three plant types.

875 (PS 13)

STORAGE ALTERS PHOSPHOLIPID LEVELS IN LIGHTLY PROCESSED CARROTS

Geno A. Picchioni*, Alley E. Watada, and Bruce D. Whitaker, Horticultural Crops Quality Laboratory, ARS, USDA, Beltsville, MD 20705-2350

Lipid metabolism in lightly-processed vegetables has received little evaluation. This study monitored changes in phospholipid (PL) concentrations of shredded carrots during a 10-day storage period at 10 C and 95% RH. Following shred preparation on day 0, total tissue PL (molar basis) increased by 15%, 33%, and 47% within 2, 5, and 10 days, respectively. PL classes were then separated using normal phase HPLC, a gradient system of isopropanol:hexane:water, and an evaporative light scattering detector. Together, phosphatidylcholine (PC) and phosphatidylethanolamine (PE) comprised over 75% of total PL, and increased by 23-26% after 10 days (μg/g dry weight basis). However, concentrations of phosphatidic acid (PA), usually regarded as a membrane degradation product, increased nearly 100% by day 10. These data suggest that prolonged storage of carrot shreds may greatly affect rates of net PL synthesis and catabolism.

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876 (PS 13)

INCREASE IN ACID INVERTASE ACTIVITY AND ACCUMULATION OF REDUCING SUGAR IN POTATOES STORED AT LOW TEMPERATURES AND PURIFICATION OF ACID INVERTASE

Dingbo Zhou* and Theophanes Solomos, Department of Horticulture, University of Maryland, College Park, MD 20742-5611

It is well known that storage of potato tubers at chilling temperatures results in an increase in the content of simple sugars, mainly sucrose, glucose, and fructose. We have observed that in Russet Burbank potatoes sucrose is the first sugar to accumulate, followed by a rise in glucose and fructose. The ratio of the increment of glucose to fructose is one, indicating that sucrose is the sole source for the reducing sugars. Our data show that there is a close temporal relationship between the accumulation of reducing sugars and rise in the activity of acid invertase (AI). Purification of combining Con A-Sepharose 4B affinity followed by DEAE-Sephacel ion exchange columns resulted in 144-fold purification of AI. SDS-PAGE indicating that the above procedure resulted in the concentration of 58 kDa polypeptide. IEF electrophoresis revealed the presence of five isoforms of AI with the following pI: 5.16, 5.25, 5.37, 5.55, 5.85. Two-D gel electrophoresis (native-to-denature) showed that a polypeptide of 49.48 kDa was associated with all isoforms of AI. There were also two addition polypeptides with 37.94 and 20.07 kDa which could be breakdown products of the 58 kDa protein or subunits of AI.

877 (PS 13)

DOES SILVER INHIBIT ETHYLENE ACTION THROUGH EFFECTS ON APOPLASTIC ENZYMES?

Joseph E. Curran* and Michael Knee, Department of Horticulture, The Ohio State University, 2001 Fyffe Ct, Columbus, OH, 43210-1096

The mechanism by which silver salts interfere with ethylene action in plants is unknown. Prior research indicates that silver acts outside the plasma membrane. We tested a number of plant apoplastic enzymes for inhibition by silver salts. Tomato (*Lycopersicon esculentum*) fruit pericarp cell wall enzymes, phosphatase, cellulase, peroxidase and polygalacturonase were not inhibited by 100$\mu$M $AgNO_3$. At 100$\mu$M $AgNO_3$ pectin methyl esterase was inhibited 24.9% and invertase 68.6%; $\beta$-galactosidase was inhibited 98.0% by 10$\mu$M $AgNO_3$. $\beta$-Galactosidase and invertase were not inhibited by silver thiosulfate (STS) at concentrations commonly used to inhibit ethylene action. In other experiments, pea (*Pisum sativum*) sub-apical hooks were excised and tested *in vivo* for NADH-ferricyanide oxidoreductase activity. This enzyme was inhibited by 1$\mu$M $AgNO_3$ and showed some inhibition by STS. These results indicate that the tomato cell wall enzymes tested are not involved in silver inhibition of plant responses to ethylene. The possible involvement of the oxidoreductase and other plasma membrane enzymes in ethylene action are being considered.

878 (PS 13)

MODELING DISTRIBUTION OF STEADY-STATE $O_2$ LEVELS IN MODIFIED ATMOSPHERE PACKAGES: AN APPROACH FOR DESIGNING SAFE PACKAGES

P. Chowdary Talasila*, Dennis W. Joles and Arthur C. Cameron, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325

Steady-state $O_2$ levels in modified atmosphere (MA) packages of fruits or vegetables may vary from target $O_2$ levels due to variation in $O_2$ uptake and film permeability. Successful MA package systems must be designed such that variation in $O_2$ uptake will not cause undesirable changes to product quality. Such changes could include fermentation and off-flavor development as well as growth of dangerous human pathogens. A computer model was developed to predict the distribution of package $O_2$ levels for a product of any given $O_2$ uptake characteristics including the coefficient of variation. The model was used to predict appropriate target $O_2$ levels for any commodity given a lower $O_2$ limit for safe storage and the percent of packages which can be tolerated at unsafe levels. For instance, if it is tolerable to have 1 in 1000 MA packages of cut broccoli reach less than 0.5 kPa $O_2$ at steady-state, the model predicts that the appropriate target $O_2$ at 0C should be about 1.75 kPa if the coefficient of variation of $O_2$ uptake is 10%. Empirical support for the model will be presented.

879 (PS 13)

MODIFIED ATMOSPHERE PACKAGING OF BEDDING PLANTS AND PLUG SEEDLINGS

R.D. Berghage*, N.K. Lownds, and M.M. Wall, New Mexico State University, Las Cruces, NM 88003

Poor post-production handling of bedding and seedling plants by mass-market outlets causes substantial quality reductions and product losses. Modified atmosphere packaging (MAP) may be a means to extend postharvest longevity and ease bedding plant handling. MAP, using heat sealed polyethylene bags, was tested with pansy, marigold, geranium, impatiens, California poppy, gazania, tomato, and pepper seedlings. Equilibrium $O_2$ levels of 5-15% were generally reached within one to two weeks, while $CO_2$ increased to 5% or more of the package atmosphere at equilibrium. Ethylene accumulated to more than .5ppm within 24 hours in some packages. Marigold seedlings had obvious leaf and stem distortion after 2-3 days. Maximum useful storage time varied from 2 weeks for tomato to greater than 8 weeks for pansy at 10C. Tomato and pepper seedlings were test marketed at a local supermarket.

880 (PS 13)

POSTHARVEST HANDLING OF *CRASPEDIA GLOBOSA* BENTH.

Terri Woods Starman* and David C. Annis, Department of Ornamental Horticulture and Landscape Design, University of Tennessee, Knoxville, TN 37901-1071

A series of postharvest experiments were conducted with cut flowers of *Craspedia globosa* in an effort to open bud-harvested flowers, determine usefulness of preservatives (sucrose + bactericide), and assess the ability of the flowers to withstand long-term dry storage at 4° C. Bud-harvested flowers pulsed with 20% sucrose solution then held in deionized water (DI) had a longer postharvest life (harvest to senescence) but not vase life (maturity to senescence), and a greater increase in flower diameter during development as the pulse duration increased from 0 to 48 h. Percentage of flowers reaching maturity was 67% regardless of pulse duration. In a second experiment, pulsing with sucrose concentrations of 20 or 25% for 48 or 72 h increased the percentage of flowers reaching maturity to 75% and reduced time of development. This did not increase vase life compared to non-pulsed flowers. Increasing the sucrose concentration in the pulse treatment up to 40% did not increase percentage of flowers opening to maturity. Partially-open harvested flowers treated with 25% sucrose pulse for 48 h had a longer postharvest life than those held in DI or 2% sucrose holding solution. Neither a 20% sucrose pulse nor 2 and 4% holding solutions increased vase life of mature harvested flowers compared to DI. Mature harvested flowers retained a long vase life after 1 or 2 weeks of dry storage.

881 (PS 13)

SIMULATED TRANSPORT AND POSTPRODUCTION OF LILIES

Terril A. Nell*, A. A. De Hertogh, Ria T. Leonard and James E. Barrett, University of Florida, Gainesville, FL 32611 and North Carolina State University, Raleigh, NC 27695

Simulated transport (ST) of 'Aristocrat', 'Polka' and 'Horizon' flowering Lilies was conducted at 2, 7 or 13C for 3, 6 or 9 days, then plants were held at 21±2C at 10 $\mu mol \cdot s^{-1} \cdot m^{-2}$ for postproduction evaluations. Number of open flowers was reduced for 'Polka' at ST of 9 days at 13C, while 'Aristocrat' and 'Horizon' were unaffected. Differences in individual flower longevity were found between the first and last open flowers. First open flower longevity was reduced by ST of 9 days and last open flower longevity was reduced by ST of 7 and 13C for both 'Polka' and 'Horizon'. ST for 9 days at 13C increased flower diameter and decreased whole plant longevity.

Exp. 2. Postproduction evaluation of 'Stargazer' and 'Aristocrat' were conducted using 18, 19.5 or 21C at 8 or 16 $\mu mol \cdot s^{-1} \cdot m^{-2}$. Number of open flowers was unaffected by treatments, while flower longevity and whole plant longevity were greatest at 18C.

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882 (PS 13)

INSECTICIDAL CONTROLLED ATMOSPHERES FOR WHITEFLY DISINFESTATION

Susan S. Han* and Jennifer Nobel, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Whitefly infestation arises frequently from plant materials that were infested at the start of the season. Use of insecticidal controlled atmospheres (CA) with $O_2$ levels < 1% and/or $CO_2$ levels > 50% have proved effective in killing various species of insects on edible commodities. A CA treatment may also be used to eliminate whitefly on floricultural products. Our studies on the effects of insecticidal CA on greenhouse whitefly (*Trialeurodes vaporarium*) showed that elevated $CO_2$ (25% or 50%) eliminated all adult greenhouse whitefly in ≤10 hours but the same treatment had little effect on eggs and pupae. Further investigation revealed that insecticidal low oxygen treatment has a greater effect and 100% mortality of eggs, nymphs, and adults were obtained with 8, 4, and ≤2 hr of anoxic conditions (100% $N_2$), respectively. Preliminary trials also indicated that 8 hr of anoxic atmosphere prevents the emergence of pupae. The use of no or low-$O_2$ CA is, thus, potentially a good treatment for elimination of all stages of whitefly.

883 (PS 13)

CARBOHYDRATE STATUS AND POSTHARVEST QUALITY OF MINIATURE ROSES GROWN UNDER CARBON DIOXIDE ENRICHMENT

N. C. Rajapakse*, D. G. Clark and J. W. Kelly, Department of Horticulture Clemson University, Clemson, SC 29634-0375.

The role of $CO_2$ enrichment on carbohydrate status and postharvest quality of miniature roses was investigated. Plants were grown in 350, 700 or 1050 $\mu l \cdot liter^{-1}$ $CO_2$ until they reached flowering stage. Stomatal resistance was increased (≈25%) by 700 or 1050 compared to 350 $\mu l \cdot liter^{-1}$ $CO_2$. Both 700 and 1050 $\mu l \cdot liter^{-1}$ $CO_2$ increased leaf sucrose but had no effect on stem sucrose concentration. However, the increase in leaf sucrose content was small (≈10% ). $CO_2$ enrichment did not affect leaf glucose but increased stem glucose concentration. Leaf and stem fructose was higher in 350 than in 700 or 1050 $\mu l \cdot liter^{-1}$ $CO_2$. Leaf and stem starch concentration increased over three-fold as $CO_2$ increased from 350 to 700 $\mu l \cdot liter^{-1}$. Both 700 and 1050 $\mu l \cdot liter^{-1}$ $CO_2$ reduced sucrose:starch ratio by 73% compared to low $CO_2$ level. $CO_2$ enrichment did not affect the over all visual quality or percentage leaf yellowing after 5 days in the interior environment of plants stored at 4 or 16C. Plants stored at 16C showed about three-fold increase in leaf yellowing compared to that of plants stored at 4C under any $CO_2$ treatment. Although $CO_2$ enrichment increased the carbohydrate status of the plants, our results do not support the hypothesis that increase in carbohydrate status play a role in improved postharvest quality and reduction in leaf yellowing of miniature roses.

884 (PS 13)

**RESPONSE DIFFERENCES BETWEEN AVOCADO AND MANGO FRUIT EXPOSED TO INSECTICIDAL MODIFIED ATMOSPHERE**

Marisela Rivera Domínguez, Elhadi M. Yahia* and Luz Vázquez Moreno, Centro de Investigación en Alimentación y Desarrollo, A.C., A.P. 1735, Hermosillo, Sonora, 83000, México.

Atmospheres with very low levels of $O_2$ (≤0.5%) and/or very high levels of $CO_2$ (≥50%) were reported to be insecticidal, and thus have a potential for postharvest insect control in horticultural crops. Our previous studies have shown that avocado fruit (Persea americana Mill cv. Hass) is very sensitive, while mango fruit (Mangifera indica L. cv Keitt) is very tolerant to these extreme atmospheres. The objective of this study was to investigate the differences in responses of the two fruits to insecticidal atmospheres. Fruits were evaluated after storage in a static modified atmosphere (MA) of < 0.4% $O_2$ and up to 80% $CO_2$ for 0, 1, 2, and 3 days at 20°C. Avocado produced intensive fermentative odor in the second day of storage while mango did not present any throughout the 3 days. Pyruvate concentration was very low in both fruits. Lactate concentration was higher in avocado and has accumulated more in MA than in air stored fruits. Avocado had higher activity of alcohol dehydrogenase (ADH) and lactate dehydrogenase (LDH), but less activity of pyruvate decarboxylase (PDC) than mango. There were no major differences in the specific activity of ADH, PDC, and LDH between air and MA stored fruits. Avocado and mango fruit differ in their biochemical responses to insecticidal (extreme) atmosphere. The basis of these differences in relation to fruit sensitivity/tolerance will be discussed.

885 (PS 13)

MACROPHYLLA DECLINE: A NEWLY DESCRIBED DISORDER IN CITRUS

Kathryn C. Taylor* and Michael Meiners, Department of Plant Sciences, 303 Forbes Building, University of Arizona, Tucson, AZ. 85721

Macrophylla decline was observed primarily in lemons on the macrophylla rootstock (*Citrus macrophylla*, Wester). This disorder is characterized by foliar zinc deficiency symptoms with zinc accumulation in trunk phloem above the bud union. Trees show symptoms of twig dieback and are less thrifty in appearance compared to the same cultivars on other rootstocks. These characteristics are very similar to a citrus disorder of humid citrus production regions, citrus blight. Citrus blight affects the more vigorous rootstocks (a characteristic of Macrophylla) such as the extremely blight susceptible rough lemon rootstock. In the humid regions, macrophylla is considered somewhat susceptible to blight. Experiments are currently underway to assess the water conductivity of xylem in trees on macrophylla and to screen for the presence of citrus blight specific proteins.

886 (PS 13)

FREEZING TOLERANCE OF SALT-AND COLD-ACCLIMATED CITRUS AND PONCIRUS SPECIES

Ilhami Tozlu*, Gloria A. Moore, and Charles L. Guy, Horticultural Sciences and Environmental Horticulture Departments, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611

It has been previously established that cold acclimation increases freezing tolerance in *Citrus*. Because both salt and cold streeses are osmotic stresses, salt application may also increase freezing tolerance. Freezing tolerance of salt treated 'Pineapple' orange (*C. sinensis* [L.] Osb.), large pink pummelo (*C. grandis* [L.] Osb.), and Pomeroy trifoliate orange (*Poncirus trifoliata* [L.] Raf.) seedlings is being examined. $LT_{50}$s for each species under our freezing conditions were established by subjecting nonacclimated and cold acclimated plants to temperatures ranging from 0 to -19°. Seedlings were treated with various concentrations of NaCl (0, 40, 80, and 150 mM) under cold-acclimating and nonacclimating conditions for 2 months, then subjected to freeze stress and examined for ability to recover. In an initial trial, pummelo seedings treated with 40 and 80 mM salt under cold-acclimating conditions displayed an increase in freezing tolerance, while exposure to any level of salt decreased freezing tolerance of sweet orange and trifoliate orange seedlings.

887 (PS 13)

THE INFLUENCE OF METHYL BROMIDE FUMIGATION ON THE STORAGE LIFE OF 'HASS' AVOCADO

M. L. Arpaia*[1], L. G. Houck[2], P. L. Hartsell[2], S. L. Ontai[1], J. S. Reints, Jr.[1], [1]Dept. of Botany and Plant Sciences, Univerity of California, Riverside, CA 92521; [2]USDA-ARS, Horticultural Crops Research Laboratory, 2021 S. Peach Ave., Fresno, CA 93727

Methyl bromide fumigation (MB) is allowed as a disinfestation treatment for fruit flies. A 2 year study was undertaken to examine the effect of MB on the storage quality of 'Hass' avocado. Fruit were obtained from a commercial packinghouse in both years. In 1991, fruit were treated within 24 hours of harvest or after 1 week of 5C storage either at 21 or 30C (4 hr. aeration). In 1992, fruit were fumigated at 30C then aerated for either 2.5 or 5 hr. A comparison to a quarantine cold treatment (14 days at 1C) was included in 1992. Fruit were evaluated after 0, 2, or 4 weeks storage. In both years there was considerable variability between grower lots, however, fruit that were fumigated had higher levels of weight loss, decay, and external (1992 only) and internal discoloration after 4 wks. of storage. Neither the timing of fumigation (1991) nor the duration of aeration (1992) had a significant impact on fruit quality. Fruit held at 1C generally had less internal discoloration after 4 weeks than MB treated fruit.

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888 (PS 13)

INFLUENCE OF ROOTSTOCK, SOIL TEMPERATURE, PHOTOPERIOD, AND FORCING METHOD ON GROWTH OF CITRUS NURSERY TREES

Ali A. Al-Jaleel* and J. G. Williamson, Horticultural Sciences Department, University of Florida, Gainesville, FL 32611.

Three experiments were conducted to determine the effect of rootstock, soil temperature, photoperiod and forcing method on scion budbreak and growth of Swingle citrumelo [*Citrus paradisi* (L.) Raf. x *Poncirus trifoliata* (L.) Osb.] and Cleopatra mandarin [*C. reticulata* Blanco] seedlings budded with 'Hamlin' orange [*C. sinensis* (L.) Osb.]. In experiment 1, budded Swingle (S) and Cleopatra (C) seedlings were exposed to root temperatures of (15 or 25°C) for six weeks following scion bud forcing. In experiment 2, budded S and C seedlings were grown in a greenhouse using three photoperiods (8, 12, and 16 hours). In a third experiment, scion buds were forced by: (1) cutting off the seedling top; (2) bending the seedling top over; or (3) bending plus 6-benzylamino purine (500 ppm) and grown at two soil temperatures (15 or 25°C). For S, the high soil temperature (25°C) resulted in greater percent scion budbreak, a shorter period from forcing to budbreak, and greater scion growth than the low soil temperature. However, for C, there was no difference in growth between high and low soil temperatures. Cutting forced buds of S plants better than bending at low soil temperatures. But scion growth was less compared to cutting at high soil temperatures. Photoperiod and the hormonal treatment had little effect on budbreak and scion growth.

889 (PS 13)

**"KEITT' MANGO STORAGE UNDER CONTROLLED AND MODIFIED ATMOSPHERE.**

Gustavo González A.; R. Báez-Sañudo*; J. Siller-Cepeda, A. Gardea and C. Vázquez. C.I.A.D., A.C., P.O. Box 1735, Hermosillo, Sonora. 83000 México. CIAD/DTAOV/RC/93/10.

México is an important mango producer. During its marketing is necessary to maintain fruit quality for long periods to access distant markets. Modified (MA) and controlled (CA) atmospheres are used in some tropical fruits to attain these goals. In this work, we evaluated Keitt mangoes quality under CA (low $O_2 \leq 0.3\%$) and MA with three low density polyethylene (LDP) films (100, 200 and 300 mils) during six days. CA fruit treated and LDP packed were stored for 30 days at 10C. Every three days, samples from CA and MA were evaluated, and every ten days a lot of treated fruits were transferred to 20C to determine fruit quality changes. We found that both, CA and MA (using LDP) delayed weight and firmness losses. Fruits kept a good appearance with a significative delay of the maturity process. However, fruit packed with 200 and 300 mils LDP developed a fermented taste after 10 days at 10C. Our conclusions suggest that these treatments prolong marketing and storage life of "Keitt" mangoes.

890 (PS 13)

**ASCORBIC ACID AND QUALITY LOSSES OF 'VALENCIA' ORANGE STORED ON THE TREE.**

Jorge Siller-Cepeda, R. Báez-Sañudo*, M. Angulo, J. Durón, J. Nuñez, E. Bringas and M. Báez. C.I.A.D., A.C. and C.I.A.N.O., Apdo. Postal 1735, Hermosillo, Sonora. 83000 México. CIAD/DTAOV/RC/93/11.

On-tree storage of Citrus has been a common practice to prolong marketing season, even for those fruits reaching legal maturity. Under this situation, fruit quality losses are dependent upon the length of stored period. On this work, we evaluated the effect that on-tree storage had over the level and form of ascorbic acid, as well as, the quality of fruit harvested at different intervals after legal maturity. Treatments consisted on harvesting fruits at seven different dates beginning on 18 March (legal maturity) and on 6 May, 21 May, 23 June, 17 July, 28 August and 14 September, 1992. Quality variables evaluated were: diameter, ring thickness, weight, color (chroma, hue and value), firmness, pH, soluble solids, tritatable acidity, juice content, and ascorbic acid content and form. Fruit weight fruit and pH increased with harvesting date. Color in its three aspects decreased, indicative of value loss, change from yellow to green, and defined chroma colors. Citric acid drop drastically, and although degree Brix was almost constant, the Citric acid/Brix increased from 15 to 38, representing fruit taste loss. Ascorbic acid decreased, while its oxidized form increased with successive harvesting dates.

891 (PS 13)

SOLUBILIZATION AND DEPOLYMERIZATION OF PECTINS DURING AVOCADO FRUIT RIPENING

Donald J. Huber* and Erin M. O'Donoghue, Horticultural Sciences Dept., University of Florida, Gainesville, FL 32611-0690

The dramatic softening of avocado fruit is frequently attributed to endo-*B*-1,4-glucanase, an enzyme which accumulates to high levels during ripening. Definitive proof is lacking, however, and the in vivo function of this protein remains to be determined. In this study, we examined the potential involvement of pectic polysaccharides in avocado fruit ripening. Soluble uronic acids increased dramatically during avocado ripening, ranging from 30 ug/mg (15% of total uronic acids) in preripe fruit to 180 ug/mg (90% of total) in ripe fruit. During this period, soluble pectins exhibited dramatic downshifts in mol wt along with a loss in associated neutral sugars, primarily GAL and ARA. Quantities of oligomeric uronic acids were also recovered, but only during the latter stages of ripening. The degree of depolymerization observed with avocado fruit far exceeds that reported for tomato fruit; however, differences can not be explained on the basis of the activity of extractable polygalacturonase.

892 (PS 14)

RESPONSE OF WOODY PLANTS TO KANAMYCIN AND BIALAPHOS

John E. Preece, Sharon A. Bates, Marta E. Chytla, A. Virginia Freire, Lynn M. Long*, J. W. Van Sambeek, Gerald R. Gaffney, John H. Yopp, and David A. Lightfoot, Departments of Plant and Soil Science, Plant Biology, and Forestry, Southern Illinois University, Carbondale, IL 62901

Resistance to kanamycin (kan) and bialaphos is commonly used to select for transgenic plants. To determine inhibitory levels for in vitro selection, nontransformed tissues of arabica coffee, white ash, black walnut, and Rhododendron 'P.J.M. Hybrids' were incubated in media containing concentrations from 0 to 400 mg/liter kan or 0 to 25 mg/liter bialaphos. Callus from coffee leaf explants was completely inhibited by 100 mg/liter kan or 1 mg/liter bialaphos. Shoot organogenesis, callus and epicotyl growth from white ash seeds were inhibited by 20 mg/liter kan or 5 mg/liter bialaphos. Secondary embryogenesis from black walnut somatic embryos was mostly inhibited by 40 mg/liter kan and totally inhibited by 1 mg/liter bialaphos. Shoot organogenesis from rhododendron leaf explants was inhibited by 10 mg/liter kan or 10 mg/liter bialaphos.

893 (PS 14)

STUDIES ON CAFFEA ARABICA GENETIC TRANSFORMATION

A. Virginia Freire*, David A. Lightfoot and John E. Preece, Department of Plant and Soil Science, Southern Illinois University at Carbondale, Carbondale IL 62901.

Attempts to transform somatic embryos of Caffea sp. with A.tumefaciens LBA4404 pBI121.1 failed (C. Coyne and D. Lightfoot unpublished). In order to investigate the possibility of genotype interactions in Agrobacterium transformation of Caffea sp., leaf explants of the coffee cultivar Caturra were inoculated with 4 tumorigenic Agrobacterium strains. Callus formed on both control leaf explants and those inoculated with A. rhizogenes A4. However, callus did not continue autonomous growth when subcultured. The activity of 24 tumorigenic forming Agrobacterium strains was determined by inoculating the stems and leaves of kalanchoë, tomato, and carrot. Positive results were obtained with 14 strains. Three of these strains were genetically transformed by introducing the plasmid pBI121.1. Additional experiments on coffee leaf and internode explants inoculated with the 14 active Agrobacterium strains as well as the 3 transformed strains have been conducted.

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894 (PS 14)
ISOZYME CHARACTERIZATION IN *ALSTROEMERIA* SPECIES AND CULTIVARS

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

Isozymes have been used since the 1960's to identify species and cultivars in many different genera in the plant and animal kingdom. Each species has a unique banding pattern for its various isozymes with the number of detectable isozymes dependent on factors such as the number of genes coding for the enzyme, the number of alleles of each gene, the quarternary structure of the enzyme and the possible formation of intergenic enzymes. *Alstroemeria* is an important cut flower currently ranked 4th in production in the U.S. The cultivars that are available to the growers have largely been developed in England and the Netherlands. The origin of these cultivars has not been well documented. As a consequence, cultivar development in the U.S. cannot easily resynthesize new cultivars from the original parents used in Europe. We are currently using isozymes to characterize some of the species which are thought to have been the progenitors of the commercial hybrids. These isozyme systems are then used to screen available hybrids for determination of the parental origin of the hybrids. This information could be used to narrow the choice of parents to be used in a breeding program for the development of the U.S. hybrids.

895 (PS 14)
GENETIC TRANSFORMATION OF ROSE (*ROSA* SPP) USING THE BIOLISTIC PROCESS

Mark. S. Strefeler*, Department. of Horticultural Science, University of Minnesota, 305 Alderman Hall, 1970 Folwell Ave, St. Paul, MN 55108.

Genetic transformation of cut roses may greatly facilitate cultivar improvement programs by shortening the time required to introduce new genes into elite germplasm. The biolistic process offers a very promising method for the genetic transformation of roses.

Several factors that have a significant affect on transformation efficiency were examined in an effort to optimize the biolistic process for gene transfer in roses. The factors examined were type of tissue (leaf segments, petioles, callus, etc.), bombardment distance, the number of bombardments, DNA construct and microcarrier velocity.

Two constructs of the reporter gene, ß-GUS, were examined to determine which construct provided the highest level of expression. Only the construct designated pBI 426 provided ß-GUS positive cells in leaf and callus tissue. This construct was used in all subsequent experiments.

Experiments to find the optimum number of bombardments and rupture disk pressure were carried out using leaf and callus tissue and 1.6 µm gold particles. The optimum number of bombardments per sample was three for leaf tissue. The optimum rupture disk pressure was 900 p.s.i. for leaf and callus tissue.

Meristems of axillary buds are being bombarded in situ on stem-bud explants. These should yield transgenic rose plantlets in 3 to 4 weeks.

896 (PS 14)
TRANSFORMATION OF *GLADIOLUS* FOLLOWING PARTICLE BOMBARDMENT

Kathryn Kamo*, Alan Blowers[1], Franzine Smith[1], and Katerina Serlemitsos, Florist & Nursery Crops, U.S.D.A., Beltsville, MD 20705-2350, [1]Sanford Scientific, Inc., 877 Marshall Road, Waterloo, NY 13165

A genetic transformation system has been developed utilizing *Gladiolus* suspension cells bombarded with high-velocity DNA coated particles. Transient β-glucuronidase (GUS) expression levels from the *uid*A gene were measured to assess efficiency of DNA delivery following particle bombardment. We have determined that 1) non-regenerable cells express higher levels of GUS activity than regenerable cells; 2) gold particles are superior to tungsten for DNA delivery; 3) maximum GUS expression occurs in suspension cells bombarded 10-13 days after subculture; and 4) incubation of bombarded cells in osmoticum-containing medium after particle bombardment enhances GUS expression levels. Several gene promoters have been evaluated for their ability to direct GUS expression in *Gladiolus* and a putative stably-transformed *Gladiolus* callus has been isolated.

897 (PS 14)
IMPROVED FREQUENCIES OF *AGROBACTERIUM*-MEDIATED TRANSFORMATION IN *CITRUS*

Alejandra Gutiérrez-E.*, Gloria A. Moore, Colette Jacono, Susan Lawrence, Michael McCaffery and Kenneth Cline, Horticultural Sciences Department, Institute of Food and Agricultural Science, University of Florida, Gainesville, FL 32611

We have previously developed a protocol for the *Agrobacterium*-mediated transformation of internodal stem sections of *Citrus* seedlings [Moore et al., Plant Cell Rep. (1992) 11:238-242]. However, most studies were done with a single genotype, Carrizo citrange [*C. sinensis* (L.) Osb. x *Poncirus trifoliata* (L.) Raf.]; putatively transformed, ß-glucuronidase positive (GUS$^+$) shoots were obtained infrequently; and, rooting of shoots was problematic. Recent studies have led to the development of an improved protocol for *Citrus* transformation that is applicable to a range of citrus types. Factors influencing transformation frequencies included plant genotype, *Agrobacterium* strain used for inoculation, and, especially, vector plasmid used. The effect of wounding the explant tissue by particle bombardment prior to inoculation with *Agrobacterium* was also evaluated. Rooting frequency of regenerated shoots was found to be influenced by the concentration of benzyladenine in the regeneration medium and was increased through the use of an improved soil mixture.

898 (PS 14)
GENETIC MAPPING OF RANDOM AMPLIFIED POLYMORPHIC DNA (RAPD) MARKERS IN *CITRUS*

Qinyin Cai*, Charles Guy, and Gloria A. Moore, Environmental Horticulture and Horticultural Sciences Departments, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611

Genetic mapping with RAPD markers has been initiated in *Citrus*. Reproducible polymorphism of amplified DNA fragments has been revealed with approximately half of the 80 random primers thus far tested. Apparent segregating loci revealed with these primers are being analyzed for reproducibility, inheritance, and linkage using 60 $BC_1$ progeny from an intergeneric cross of *Citrus grandis* (L.) Osb. x [*C. grandis* x *Poncirus trifoliata* (L.) Raf.]. This progeny population has been previously used to map 57 isozyme and RFLP markers [Durham et al., Theor. Appl. Genet. (1992) 84:39]. Thus far 70 RAPD markers have been placed on the map; a current map will be presented. We hope to use a highly populated linkage map to map quantitative trait loci for cold tolerance in this cross between very cold-sensitive *C. grandis* and extremely cold-hardy *P. trifoliata*. As a part of this project, we have thus far isolated 6 unique cold acclimation responsive cDNA clones through differential screening of a library constructed from cold acclimated tissue of *P. trifoliata*. Work is also in progress to place these clones on the linkage map.

899 (PS 14)
IN VITRO SELECTION AND MOLECULAR CHARACTERIZATION OF MELOIDOGYNE INCOGNITA-TOLERANT PEACH SOMACLONES

G. Hashmi, L.R. Krusberg and R. Meyer, Department of Botany, University of Maryland, College Park, MD 20742. R. N. Huettel, APHIS, Hyattsville, MD 20782. F. A. Hammerschlag*, Plant Molecular Biology Laboratory, USDA/ARS, Beltsville, MD 20705-2350

Peach regenerants 156-1, 156-7, 156-11, 156-12 and 30-1, 30-2, 30-4, 30-6, 30-7 and 30-8 were obtained from immature embryo #156 from highly susceptible cv. Sunhigh and from immature embryo #30 from moderately tolerant cv. Redhaven, respectively. Significantly higher numbers of nematodes developed on 156-7 and 'Sunhigh' compared with 156-1, 156-11, and 156-12, whereas no significant differences in nematode development were observed among 'Redhaven' regenerants. RAPD primers were used with the polymerase chain reaction (PCR) to identify somaclonal variation at the molecular level. Sixty RAPD primers (10-mers) were screened for markers. Genomic DNA was isolated from regenerants 156-1, 156-7, 156-11, 156-12, and cv. Sunhigh using the CTAB method. DNA was amplified with each of the sixty primers. Although 35 primers produced results with scoreable and consistent bands, RAPD polymorphism was observed with only 10 of the primers.

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900 (PS 14)

**RAPD MOLECULAR MARKERS IN WATERMELON**

X. P. Zhang*, B. B. Rhodes, Dept. of Horticulture, and H. Skorupska, Dept. of Agronomy and Soils and Biological Sciences, Clemson University, Clemson, SC 29634

We examined the RAPD (random amplified polymorphic DNA) technique in our efforts toward mapping the watermelon genome. Three cultigens: Dixielee, G17AB and New Hampshire Midget (NHM), and the primitive watermelon PI 296341 and the hybrid NHM x PI 296341 were tested for polymorphic RAPD markers with 53 10-mer primers. Among total of 159 readable bands, 89 (62.3%) of the bands were polymorphic among the four accessions and 82 (51.6%) of the bands were polymorphic between NHM and PI 296341, but only 16 (10.1%) were polymorphic within the three cultigens. Results of cluster analysis based on the RAPD data were correlated with agronomic characters. The watermelon genome size was estimated by flow cytometer analysis to be relatively small, ca. 0.98 pg. The large number of polymorphic loci and the relatively small genome will enable us to develop a high density linkage map. Cosegregation analysis is under way to establish linkage relationships between the RAPD markers and estimate recombination distances between agronomic traits and molecular markers.

901 (PS 14)

**USE OF RANDOM AMPLIFIED POLYMORPHIC DNA VARIETIES (RAPD) TO DISTINGUISH SHORT-DAY GRANO-TYPE ONION VARIETIES**

Virginia P. Roxas and Ellen B. Peffley*, Department of Agronomy, Horticulture, and Entomology, Texas Tech University, Lubbock, TX 79409-2122

Nineteen random primers yielded 36 PCR-amplified products of Allium cepa DNA. RAPD profiles of each of 12 short-day grano-type onion varieties used as breeding lines or grown commercially in Texas and Southern U.S. were compared. Several PCR products were unique among the varieties and can be used to differentiate among the onion cultivars investigated. A phenogram of the varieties based on the co-occurrences of the PCR products was derived.

902 (PS 14)

**USE OF PCR AND RFLP TECHNIQUES TO MAP THE *SW-5* LOCUS CONFERRING RESISTANCE TO TOMATO SPOTTED WILT VIRUS (TSWV) IN TOMATOES**

M.R. Stevens*, D.D. Rhoads, E.M. Lamb, R.C. Gegerich and T.E. Morelock, Dept. of Horticulture and Forestry, Biological Sciences and Plant Pathology, University of Arkansas, Fayetteville, AR 72701

An $F_2$ population of an interspecific hybrid between a homozygous (*Sw-5*) TSWV resistant *Lycopersicon esculentum* cultivar and the susceptible *L. pennellii* LA 716 accession was tested repeatedly for resistance to TSWV. The ratio was three resistant to one susceptible. Previous research with isozymes and phenotypic markes suggested that *Sw-5* was not on chromosome one, four, eleven or twelve; and that it was possibly on seven. However, preliminary RFLP analysis using telomeric probes indicated that the resistance gene is found somewhere near TG 623 and CT 101 on chromosome five. Over 450 ten-base random primers have been used on homozygous TSWV resistant and susceptible *L. esculentum* lines to find RAPD markers to aid in isolating *Sw-5*. Several polymorphisms have been identified; however, none have been identified to segregate with the *Sw-5*.

903 (PS 14)

**EFFECT OF *AGROBACTERIUM* GROWTH STAGE AND CULTURE DENSITY ON THE TRANSFORMATION EFFICIENCY OF SWEETPOTATO**

C. Korsi Dumenyo*, E. Blay, A. Porobo Dessai and C. S. Prakash, Tuskegee University, Plant Molecular and Cellular Genetics Lab, School of Agriculture and Home Economics, Tuskegee, AL 36088-1641.

**The efficiency of genetic transformation of plants via *Agrobacterium* cocultivation is determined by several factors. This experiment aimed to study whether the culture age and bacterial density of *Agrobacterium tumefaciens* influenced the transformation efficiency of sweetpotato (*Ipomoea batatas*). The *A. tumefaciens* (MP90 *gus::nptII*) was cultured in LB broth (10 ml) and resuspended in half -strength MS solution prior to use. Petiole and leaf lamina explants of cultivars Regal and Rojo Blanco were cocultivated with the bacterial cultures that were 6-32 hour old. The age of the *Agrobacterium* culture used for cocultivation had a significant effect on the extent of explant area transformed. Cultures that were 24 h old (4 x$10^9$ CFU/ml) produced the highest transformation. When cultures of various ages were diluted 1, 5 and 10 times (prior to cocultivation), the extent of transformation was not significantly affected. Thus, high dilutions (up to 10 times) could be used in the sweetpotato transformation to minimize the bacterial overgrowth on the explants duing subsequent incubation. Petioles were generally more competent to transformation and had proportionately larger transformed areas when compared to leaf lamina.**

904 (PS 14)

**CRABAPPLE IDENTIFICATION BY ISOZYME ANALYSIS**

Robert Marquard* and Charlotte Chan, The Holden Arboretum, 9500 Sperry Road, Mentor, OH 44060-8199

Crabapples (*Malus* spp.) are an important group of ornamental trees that are morphologically and genetically very diverse. Crabapples are represented by 35 species (and their hybrids). Some *Malus* species freely hybridize and numerous cultivars originated as open-pollinated seedlings of questionable parentage. Isoenzyme analysis could provide a more reliable measure to verify cultivars and putative pedigrees. Five enzyme systems were well resolved and polymorphic using standard starch gel electrophoretic techniques. Enzymes evaluated include: phosphoglucose isomerase (PGI), malate dehydrogenase (MDH), 6-phosphogluconate dehydrogenase (6-PGD), aspartate aminotransferase (AAT), and phosphoglucomutase (PGM). After electrophoresis, PGI, MDH, and AAT exhibited one distinct polymorphic region of activity whereas 6-PGD and PGM exhibited at least two regions. Isoenzyme profiles were constructed for each polymorphic region for 45 crabapples which demonstrated a high degree of variability. Most cultivars could be uniquely identified using the five enzyme systems. PGM and 6-PGD were most useful in characterizing among the selected cultivars.

905 (PS 14)

**USE OF SINGLE-PRIMER DNA AMPLIFICATIONS FOR THE IDENTIFICATION OF RED MAPLE (*ACER RUBRUM* L.) CULTIVARS**

Kimberly H. Krahl*, Michael A. Dirr, Tracy M. Halward, Gary D. Kochert, and William M. Randle, Department of Horticulture, University of Georgia, Athens, GA 30602

Positive cultivar identification is often difficult or impossible based solely on morphological traits. A technique ensuring reliable, repeatable, and unique cultivar identification is needed. The use of molecular markers offers such a technique, allowing assessment of fine levels of variation directly at the DNA level. In this study, RAPD (Random Amplified Polymorphic DNA) markers were investigated for their utility to identify red maple cultivars. Three out of nineteen primers tested resulted in unique banding patterns for all the maples tested, including 9 red maple clones, 5 silver maple seedlings, and 4 purported interspecific cultivars. The red maple cultivars 'Red Sunset' and 'October Glory', which are almost indistinguishable morphologically as young trees, were clearly distinguished using RAPD markers. Thus, RAPD markers provide a consistently reliable technique for red maple cultivar identification.

906 (PS 14)

**MOLECULAR CHARACTERIZATION OF THE BETA-TUBULIN GENE FAMILY IN HERBICIDE-RESISTANT AND -SUSCEPTIBLE GOOSEGRASS [*ELEUSINE INDICA* (L.) GAERTN.]**

Kirankumar S. Mysore* and Wm. V. Baird, Department of Horticulture, Clemson University, Clemson, SC 29634-0375.

Goosegrass is a noxious weed in cotton fields as well as in other agronomic and horticultural crops. Normally this weed has been effectively controlled by the pre-emergent dinitroaniline herbicides. Recently a dinitroaniline resistant biotype of goosegrass has been reported from cotton fields in the southeastern U.S.(Mudge *et al.*, 1984, Weed Science 32 : 591-94). At the subcellular level, the dinitroanilines appear to affect the stability of the microtubules by altering the polymerization/depolymerization cycle of the tubulin monomers. Therefore this herbicide would deleteriously affect vital cellular functions, such as nuclear and cell division in susceptible plants. There is a question regarding the presence and role of an altered beta-tubulin in the herbicide response phenotype expressed by the resistant biotype of goosegrass (Vaughn *et al.*, 1987, Plant Physiol 83 : 956-64 ; Waldin *et al.*, 1992, Planta 188 : 256-64). We have undertaken an analysis of the beta-tubulin gene(s) in goosegrass to clarify the role of beta tubulin in the herbicide response phenotype. Initial results, from Southern blot analysis using heterologous gene probes, indicate 4 to 6 members in the gene family. We will report the results of our on going studies to characterize the size, structure and complexity of the beta-tubulin multigene family in goosegrass.



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907 (PS 14)

GENETIC ANALYSIS OF DINITROANILINE-RESISTANT AND SUSCEPTIBLE GOOSEGRASS [*ELEUSINE INDICA* (L.) GAERTN.]

Linghe Zeng*, C. R. Werth[1], K. S. Mysore and Wm. V. Baird, Horticulture Department, Box 340375, Clemson University, Clemson, SC 29634-0375, and [1]Department of Biological Sciences, Texas Tech University, Lubbock, TX 79409-3131.

Goosegrass biotypes resistant to the dinitroaniline herbicides have recently been identified in many of the cotton growing areas of the southeastern U.S. Knowledge of the molecular basis of this resistance will be critical to understanding the genetics and evolution of this interesting and agronomically important phenotype. Our initial efforts have focused on developing bioassays (e.g., root and pollen tube growth) and identifying genetic markers (using isoenzymes, RFLP's and RAPD's) for these herbicide-response phenotypes. Although 7 of 15 isozyme systems were polymorphic in our study populations, and 63% of the among-population variance could be attributed to population location, none of the variance could be attributed to differences in herbicide response. We have identified 8 RAPD markers that are, at least, population specific. Four of these appear to be herbicide-response specific in our initial evaluations. We have initiated an RFLP analysis using heterologous, ß-tubulin gene probes. The genetic markers will be used to identify hybrid progeny of a cross between inbred lines of resistant and susceptible biotypes, in order to determine the number of genes involved in the expression of resistance to the dinitroanilines.

908 (PS 14)

**GENE FLOW IN SECTION Batatas (CONVOLVULACEAE).**

Díaz, Jaime*; De la Puente, F. (International Potato Center, P.O. Box 5969, Lima, Peru) and Austin, D.F. (FAU, Boca Raton, FL 33431).

It is well known that crossability within section Batatas is a complex phenomenon because of genetic, cytogenetic and physiological implications. During 1988 to 1991 we investigated the factors involved in crossability. In the 1st stage, self-compatibility was determined/verified in I. cynanchifolia (2x), I. grandifolia (2x), I. triloba (2x), I. x leucantha (2x), I. lacunosa (2x), I. tenuissima (2x), I. ramosissima (2x) and I. cordato-triloba (2x). Additionally, self-incompatibility was verified in I. trifida (2x), I. tiliacea (4x) and I. batatas (4x,6x). It is postulated that sexual compatibility is related to a multiallelic sporophytic incompatibility system. In the second stage, 4,162 cross pollinations between 11 species were performed at La Molina and San Ramon, and 76 interspecific combinations from 110 possible theoretic combinations in a diallelic 11 x 11 design were obtained. Of 76 interspecific combinations, 38 succeded with a crossability rate ranging from 0.01 to 1.00 at La Molina. In San Ramon, of 17 interspecific combinations, 11 were succesfull when estimating crossability from 0.01 to 0.71. Considering the factors affecting crossability, it was found that latitude influences flowering synchrony in progenitors, and in the germination process, and the early death of seedlings is related to an unbalanced genome (embryo/endosperm) relationship. In interspecific crosses, it was shown that I. trifida and I. x leucantha act as "bridge species".

909 (PS 14)

**REDUCTION OF CHILLING INJURY WITH HIGH- AND LOW-TEMPERATURE CONDITIONING**

Chien Y. Wang, Beltsville Agricultural Research Center, Agricultural Research Service, USDA, Beltsville, MD 20705

The severity of chilling injury in zucchini squash stored at 5C than transferred to 20C was reduced with the prestorage treatment of 42C hot water for 30 min. The chilling injury was further reduced when squash were preconditioned at 15C for 2 days after hot water treatment but before the 5C storage. Squash stored at 15C did not develop any symptoms of chilling injury. However, weight loss was most severe in squash stored at 15C. Squash kept at 5C had the least weight loss during the 2-week storage. Weight losses were comparable in squash treated or not treated with hot water. Analysis of polyamines in squash preconditioned with high and low temperatures is in progress. The effect of hot water treatment on the changes of putrescine, spermidine, and spermine and its implication in reducing chilling injury will be discussed.

910 (PS 14)

REDUCTION OF APPLE SUNBURN WITH CELLULOSE FIBERS

Matthew K. Rogovski*, Alvan G. Gaus, and Harold J. Larsen, Rogers Mesa Research Center, Department of Horticulture, Colorado State University, 3060 Highway 92, Hotchkiss, CO 81419-9549

Reduction of heat stress disorders of 'Golden Delicious' apples, such as sunburn, has been accomplished with cellulose fibers that modify reflective fruit surface properties. Incidence of sunburn on apples, directly exposed to sunlight, was decreased from 38% for untreated fruit to 12.5% for apples treated with cellulose fibers and binding agent and to 25.1% for apples treated with the binding agent only. Field stability of the binding agent (1% colloidal suspension of corn starch) was improved over the formulation used during the previous growing season. It was found that heating the starch suspension to 121C for 15 minutes increased its stability as a binding agent. A cumulative total of 3 cm (over three events) removed enough fibers to necessitate reapplication of the reflectant. The cellulose fiber/binder residue remaining at harvest was readily removed from fruit surface with water and a brush. Specialized sprayer was developed to deliver long fiber cellulose formulations that conventional sprayers are not capable of dispensing.

911 (PS 14)

**TISSUE INJURY AND SUPERCOOLING RESPONSE OF PEACH FLOWER BUDS TO SUB-LETHAL HEAT STRESS**

Michael Wisniewski,* Glen Davis and Rajeev Arora, USDA, ARS, Appalachian Fruit Research Station, Kearneysville, WV 25430

It has been previously reported that sub-lethal heat treatments of cold hardy Azalea (45C) and grape floral buds (47-50C) for 2 hours altered deep supercooling by shifting low temperature exotherms (LTE) to warmer temperatures. Heat treatments were shown to modify suberized tissues in Azalea which may function as an ice barrier required for deep supercooling. Our study examined deep supercooling of Loring peach buds subjected to heat treatments ranging from 40 - 49C. Temperatures above 43C for 2 hours resulted in visible injury to floral tissues. However, 65% of these buds continued to exhibit deep supercooling. Tissue injury was not observed at 40C, however longer exposure durations (16-24h) were required to shift LTEs to warmer temperatures. Moderately hardy buds (avg LTE -15C) were responsive to 40C treatment whereas, extremely hardy buds (avg LTE -20C) were not. Pre-disposing extremely hardy buds to deacclimating conditions by placing twigs in water in the greenhouse for 24h, elicited a response to heat treatment and promoted warm temperature shifts of the LTE. It appears that tissue-water status of floral buds may play a role in their response to sub-lethal heat treatment.

912 (PS 14)

SUCROSE AND DEHYDRATION INDUCE GLASS TRANSITIONS DURING CRYOPRESERVATION OF STRAWBERRY PLANTLETS

Manfredo J. Seufferheld and Cecil Stushnoff, Department of Horticulture, Colorado State University, Fort Collins, CO 80523

Differential scanning calorimetry was used to study the effects of sucrose and dehydration on biophysical aspects during cryopreservation of strawberry plantlets, regenerated from leaf disks. Plantlets were encapsulated in alginate beads, soaked 24, 48, 72 and 96 hours in sucrose solutions (0 to 2.0 M) and dehydrated. Imbibition in 1.0 - 2.0 M sucrose and controlled desiccation influenced both ice nucleation and glass transitions during cryopreservation. A surprising discovery was the presence of an exotherm at -100C (sucrose 1.5 and 2.0 M samples imbibed for 48 hours and desiccated 4 hours ). The exotherm disappeared and was replaced by a glass transition when imbibition time was increased to (72 hours). Phase diagrams from the DSC data, illustrate a sucrose concentration dependency in the range of 1.0 to 2.0 M, where exotherms occur. We conclude that imbibition with sucrose, coupled with desiccation treatments, may be used to manipulate the biophysical properties of freeze tender tissues to permit successful cryopreservation. Strawberry plantlets provide an ideal model to study this behavior.

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913 (PS 14)

POLLEN VIABILITY AND FRUIT SET OF HEAT-TOLERANT AND SENSITIVE TOMATO GENOTYPES UNDER OPTIMUM AND HIGH-TEMPERATURE REGIMES

Aref Abdul-Baki* and John R. Stommel, USDA-ARS, Vegetable Laboratory, Beltsville, MD 20705-2350

Heat-tolerant and heat-sensitive tomato (*Lycopersicon esculentum* Mill.) genotypes were grown in the greenhouse under optimum and high temperature stress regimes. Levels of heat tolerance in the genotypes were established by determining percent fruit set under the high temperature regime. Under optimum temperature, fruit set in the heat-sensitive genotypes ranged from 41 to 54% and in the heat-tolerant genotypes from 45 to 91%. Under high temperature, no fruit set was observed in the heat-sensitive genotypes whereas, fruit set in the heat-tolerant genotypes ranged from 5 to 64%. In vitro germination and pollen tube growth of pollen taken from genotypes grown under optimum temperature conditions were determined before and after subjecting the pollen to 45C for 1, 2, and 4 hours. Pollen viability of heat tolerant genotypes was less affected by heat treatment than that of most heat sensitive genotypes. The results suggest that environmental factors independent of temperature may also influence pollen viability.

914 (PS 14)

CLONAL SELECTION OF COLD-TOLERANT LINES IN GRAPE CELL CULTURE

Zhang Mingpeng and C.B. Rajaskekar*, Division of Horticulture, Kansas State University, Manhattan, KS 66506

Suspension cultures of grape hybrids (Vitis spp.) were used to select cold tolerant cell lines. The cultured cells were subjected to selection pressures by cooling at $2^0$ C/h to various temperatures below the average lethal temperature ($LT_{50}$) of the cell population. The cold tolerant lines were selected based on the distribution of lethal temperatures in the population. The small fractions of cells which were more cold tolerant than the $LT_{50}$ of the population were enriched by many selection cycles. After two selection cycles, the cold tolerant lines of all three cultivars survived -9 and -9.6$^0$C ($LT_{50}$), whereas the control population survived between -2.5 and -3.2$^0$C. The increased cold tolerance in selected lines was due to shifts in the frequency and distribution of lethal cell injury in the selected population as compared to the unselected control.

915 (PS 14)

**Possible Role For Pepper Leaf Anthocyanins In Increased Tolerance To Photoinhibition During Chilling Stress**

Kenneth L. Steffen* and Esther L. Porter, Department of Horticulture, The Pennsylvania State University, University Park, PA 16802

Chilling injury is more severe in the presence of light than in the dark. Anthocyanins, commonly found in the adaxial leaf layers of certain plants, are known to screen incident solar radiation. A correlation between anthocyanin content and low temperature/light stress tolerance has been suggested. Our objective was to examine this relationship using purple-leaved (Pretty Purple) and green-leaved (Domino) pepper cultivars. At 5 weeks, Pretty Purple had a ca.10-fold higher anthocyanin content and a 50% higher chlorophyll content per area than Domino. Anthocyanins were observed in adaxial epidermal and palisade cells as well as in abaxial guard cells. Plants were grown at 25/20°C (day/night) before exposure to 4 days of chilling (8/5°C) followed by a 3 day recovery at 25/20°C. Light intensity was maintained at a constant level. Both cultivars demonstrated ca. 3-fold declines in light and bicarbonate-saturated photosynthesis following the chilling period with full recovery by 3 days. Quantum efficiency decreased ca. 3-fold in both cultivars with Domino exhibiting a more complete recovery. Variable Chl a fluorescence (Fv/Fm) decreased to 50% of control in Pretty Purple versus 25% of control in Domino, which conversely demonstrated a more complete recovery. The results suggest that anthocyanins may be protecting the photosynthetic apparatus and that differences may exist between cultivars in repair and/or energy quenching mechanisms.

916 (PS 14)

SOLUBLE SUGARS AND WINTER HARDINESS IN FLOWER BUDS OF *FORSYTHIA* SPECIES

Cindy L. Flinn* and Edward N. Ashworth, Department of Horticulture, Purdue University, West Lafayette, IN 47907

Little is known about the biochemical factors responsible for the wide range in flower bud hardiness of *Forsythia* species. In other genera, a correlation has been reported between soluble sugars, particularly raffinose and stachyose, and hardiness. Total starch and soluble sugars, their relationship to flower bud hardiness and levels of individual sugars were studied in four *Forsythia* species: *F.* x *intermedia* 'Spectabilis', *F.* x *intermedia* 'Lynwood', *F. suspensa* var. *fortunei* and *F.* 'Meadowlark'. Hardiness was determined either by sampling flower buds at intervals during controlled freezing tests or by thermal analysis. Total sugars were extracted with water/ethanol and quantified with Anthrone. Individual sugars were separated and quantified with high pressure liquid chromatography. 'Lynwood', the least hardy of the four cultivars, was killed by -16C, while 'Spectabilis, the most hardy, survived -22C in midwinter. Total sugars accumulated throughout the winter in buds, apparently at the expense of total starch, in F. 'Meadowlark' and F. *suspensa* var *fortunei*. As total sugars accumulated in 'Spectabilis', however, total starch increased slightly. Although fructose, glucose, galactose and melibiose were detected throughout the year, raffinose and stachyose, were detected only in hardy flower buds.

917 (PS 14)

CADDO SUGAR MAPLE, A HEAT-TOLERANT SOUTHERN ECOTYPE

John C. Pair, Kansas State University, Horticulture Research Center, 1901 East 95th South, Wichita, KS 67233-8351

Evaluations of heat and drought tolerant species for the great plains includes a southern ecotype of Acer saccharum, native to Caddo County, Oklahoma. Seedlings from this disjunct population have exhibited superior growth, tatter resistant foliage, and greater drought stress than most sugar maple cultivars. Fall color, although usually later than the species and somewhat variable, can be quite outstanding. Leaf tatter and pre-dawn xylem potential were equal to 'Legacy' and superior to other cultivars in the trade. Propagation of selected trees offers opportunity for cultivar selection. Ten years of growth and performance under stressful sites indicate excellent regional adaptation.

918 (PS 14)

EFFECTS OF SOIL TEXTURE, MOISTURE LEVEL, AND DEPTH OF PLANTING ON ONION FREEZING INJURY.

C.H.Rivera-Figueroa*, J. Corgan, D. Clason.
New Mexico State University. Las Cruces, NM 88003.

Three experiments were conducted to investigate the effects of soil texture, planting depth, and soil moisture level at time freezing on temperature required to kill 50 percent of onion seedlings ($LT_{50}$). In one experiment onion seedlings were sown at two planting depths and frozen at two soil moisture levels to temperatures of -7, -9, -11, -13, -15, -17, or -19 °C. In other experiments seedlings were grown in two soil textures, planted at two depths, 2 or 4 cm , and frozen to temperatures of -8, -11, -14, -16, -17, or -20 °C. The $LT_{50}$ for plants frozen in wet soil was -14.8 °C, while in dry soil the $LT_{50}$ was significantly ($p = 0.008$) higher at -11.3 °C. Neither planting depth nor soil texture had a significant effect on $LT_{50}$. At 4 cm planting depth, seedling emergence was delayed, an plant stands were less than for the 2 cm depth.

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919 (PS 14)

EFFECT OF PRETREATMENT ON THE THERMOTOLERANCE OF DORMANT Vitis vinifera cv. CABERNET SAUVIGNON HARDWOOD CUTTINGS

Robert L. Wample* and Lynn Mills. Washington State University, Irrigated Agriculture Research and Extension Center, Prosser, WA 99350

The relationship between heat tolerance and cold hardiness was examined during the winter of 1992-93. Dormant canes of Cabernet Sauvignon were collected from an experimental vineyard at approximately two to three week intervals. Samples were held overnight at 0-3 C. Subsamples were removed from storage and subjected to either room temperature for 4 1/2 hours, 45 C for 35 minutes followed by room temperature for 4 hours or held at 0-3 C. Samples were then subjected to either heat treatment (52, 54, 56, 58, or 60 C for 30 minutes) or low temperature exotherm analysis.

Pretreatment at 45 C improved the heat tolerance but did not change cold tolerance. Holding samples at room temperature resulted in a slight improvement in heat tolerance. Additional implications of these findings will be presented.

920 (PS 14)

**CHILLING REQUIREMENT AND BUDBREAK RESPONSE TO HYDROGEN CYANAMIDE IN 'FLAME SEEDLESS' GRAPES.**

Jorge Siller-Cepeda*, Guadalupe Osorio, M. Báez, A. Sanchez and J. Avalos. C.I.A.D. A.C. and C.I.A.N.O. Apdo. Postal 1735, Hermosillo, Sonora. 83000 México. CIAD/DTAOV/RC/93/08.

The scarce chilling accumulation during autumn and the high variability among years under desert conditions demands a high priority to study the interaction of chilling accumulated and hydrogen cyanamide rate to improve budbreak. Canes were collected at the onset of dormancy on 31 Oct, 1991 and stored at 4°C from 0 to 300 hours (CH). Additionally, cyanamide at 0.0, 0.025, 0.050, 0.100, 0.200, and 0.400M was sprayed to run-off every 50 CH and placed in a growth chamber (23±1°C) with additional light for budbreak evaluations. Final budbreak of control plants improved significantly with chilling accumulated from 12% on the controls up to 96% on 300 CH. Sixty percent budbreak occurred after the control plants reach 250 CH. Cyanamide rates ≤ to 0.2M increased budbreak above the control when chilling was ≤ 250 CH. After 300 CH, final budbreak was alike on all treatments, but cyanamide delayed budbreak. The most consistent treatments were 0.1 and 0.2M cyanamide rates (2 and 4% a.i. on adult vines). No significant differences were found among this treatments on final budbreak at all chilling levels; however, between 100 and 200 CH, cyanamide induced early budbreak.

921 (PS 14)

**HIGH TEMPERATURES DURING DORMANCY INFLUENCED BUDBREAK OF TABLE GRAPES CV. FLAME SEEDLESS.**

Guadalupe Osorio*, Jorge Siller-Cepeda, M. Báez and A. Sanchez. C.I.A.N.O. and C.I.A.D. A.C., Apdo. Postal 1735, Hermosillo, Sonora. 83000 México. CIAD/DTAOV/RC/93/09.

Table grape production on desert regions present a narrow period of low temperatures during dormancy, with a high oscillation between day and night temperature. Under this situations chilling accumulation and budbreak are influenced on early cultivars. Treatments consisted on continuous (100, 200 and 300) or interrupted chilling hours (CH) at 4°C, with and without 0.1M cyanamide application. The interruptions were at 100 or 200 CH for 2,4 or 6 day at temperatures of 20 or 25°C. High temperatures intervals after 100 CH affected more negatively budbreak on cyanamide treated plants than no treated, regardless of temperature. Budbreak was earlier and higher when chilling was interrupted after 200 CH for 2 days at 20°C or 4 and 6 days at 25°C and no cyanamide was applied. With cyanamide application, 200 CH interruption for 2, 4, or 6 days at 20°C reduced and delayed budbreak. At 25°C, and non cyanamide application, only 2 days interruption after 200 CH affected negatively budbreak, while 4 and 6 days intervals at this temperature stimulated budbreak. When cyanamide was applied on this treatment, no differences were found with respect to continuous CH.

922 (PS 14)

FRUIT CHARACTERISTRS OF SOME CITRUS SPECIES IN RELATION TO HEAT AND DROUGHT STRESSES

Mohamed A.Shaheen and Samir Z.El-Agamy* Faculty of Meteorology, P.O.Box 9034, Jeddah, Saudi Arabia, and Faculty of Agriculture, Assiut Univ., Assiut, Egypt.

Fruit characteristics of 8 citrus species and cultivars including orange (Valencia, Hamlin,Temple and Navel), tangarine (Dancy), lemon (Lisbon) and grapefruit (Marsh and Ruby) were studied on trees grown under strong heat and drought stresses. Environmental stresses resulted in extreme influences on fruit shape, rind thickness and color and juice percentage. Dancy tangarine and Navel orange were completely depleted from juice. Fruitstended to be round, thicker rind and less juice content in other species. TSS and ascorbic acid contents were slightly lower than their standards while acidity was markedly decreased.

923 (PS 14)

SEASONAL COLD-ACCLIMATION PATTERNS OF 'AUTUMN JOY' AND 'BRILLIANT' SEDUM

Jeffery K. Iles* and Nancy Howard Agnew, Department of Horticulture, Iowa State University, Ames, IA 50011

Electrolyte leakage and regrowth tests were performed in successive months from September to January to determine cold hardiness of container-grown *Sedum spectabile Xtelephium* L. 'Autumn Joy' and *Sedum spectabile* Boreau. 'Brilliant' plants exposed to natural temperature and photoperiod. Plant crowns were subjected to 0, -3, -6, -9, -12, -15, -18, -21, -24, or -27C in a programmable freezer. Regrowth tests were performed on whole crowns and electrolyte leakage determinations were made on excised tuberous root and crown tissues. Regrowth data indicate both cultivars had killing temperatures of -3C at the September test date, prior to the onset of cold-acclimation. By October, the killing temperature for 'Autumn Joy' had dramatically decreased to -12C, with more gradual acclimation occurring thereafter. The killing temperature for 'Brilliant' decreased from -3C in October to -18C in November. In this study, maximum hardiness was achieved on the January test date with killing temperatures of -24 and -21C for 'Autumn Joy' and 'Brilliant', respectively. Correlation coefficients suggest the electrolyte leakage procedure was able to reliably estimate 'Autumn Joy' cold hardiness at each test date, but was less accurate for 'Brilliant". Regrowth tests are tedious and qualitative, but remain reliable predictors of plant viability. Electrolyte leakage tests were successful in estimating survival potential of plants exposed to freezing temperatures using either excised crown or tuberous root tissue.

924 (PS 14)

FALL PRUNING EFFECTS COLD HARDINESS OF FIELD-GROWN CRAPE MYRTLE

C.L. Haynes*, O.M. Lindstrom[1], and M.A. Dirr, University of Georgia, Dept. of Horticulture, Athens, GA 30602-7273 [1] Dept. of Horticulture, Georgia Station, Griffin, GA 30223-1797

The effects of fall and winter pruning on cold hardiness of field-grown *Lagerstroemia* L. 'Natchez' (crape myrtle) were determined. In the first year (1990-1991) pruning prior to January reduced cold hardiness estimates of 'Natchez' crape myrtle by 3C compared to controls. In the second year (1991-1992) fall pruning also reduced cold hardiness estimates by 3C on the January and February test dates. Pruning in January or later is recommended for 'Natchez' crape myrtle to assure maximum cold hardiness. Similar cold hardiness estimates of 'Natchez' crape myrtle were obtained from field trials compared to lath tests conducted the previous year.

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925 (PS 14)

**METHANOL PRODUCTION FROM HEAT-STRESSED PEPPER AND CORN LEAF DISKS**

Jeffrey A. Anderson*, Department of Horticulture and Landscape Architecture, Oklahoma State University, Stillwater, OK 74078-0511

Pepper (*Capsicum annuum* L. 'Early Calwonder') and corn (*Zea mays* L. 'Jubilee') leaf disks exposed to high temperature stress produced ethylene, ethane, methanol, acetaldehyde, and ethanol based on comparison of retention times during gas chromatography to authentic standards. Methanol, ethanol, and acetaldehyde were also identified by mass spectroscopy. Corn leaf disks produced lower levels of ethylene, ethane and methanol, but more acetaldehyde and ethanol than pepper. Production of ethane, a by-product of lipid peroxidation, coincided with an increase in electrolyte leakage (EL) in pepper but not in corn. Compared with controls, pepper leaf disks infiltrated with linolenic acid evolved significantly greater amounts of ethane, acetaldehyde and methanol, and similar levels of ethanol. Introduction of linoleic acid did not significantly affect volatile hydrocarbon production in pepper. Electrolyte leakage and volatile hydrocarbon production were not affected by fatty acid infiltration in corn.

926 (PS 14)

REDUCING BELL PEPPER FLOWER ABSCISSION WITH ETHYLENE INHIBITORS IN FIELD EXPERIMENTS. H.C. Wien* and A.D. Turner, Dept. Fruit and Vegetable Science, Cornell University, Ithaca, NY 14853.

In previous research, pepper flower abscission has been brought about by ethylene, and prevented under greenhouse conditions by the ethylene action inhibitor silver thiosulfate (STS). Field experiments in 1991 and 1992 compared the abscission response and yield of 'Shamrock', 'Ssupersweet 860' and 'Lady Bell' when treated with foliar sprays of STS ($1x10^{-3}$M or $5x10^{-3}$M), or the ethylene synthesis inhibitor AVG (50 or 100ppm), applied at flowering. Abscission, measured a week after the chemicals were applied, was reduced from 16 to 4% in 1991, and from 16 to 5% in 1992 by the higher STS rate but not affected by AVG. 'Ssupersweet' and 'Shamrock' averaged 14% abscission during the measurement interval, while 'Lady Bell' had 8%. Treatments did not change marketable yields, but the high rate of STS increased total and cull fruit numbers by 35 and 41%, respectively. All cultivars showed similar abscission and yield responses to the treatments.

927 (PS 15)

EFFECTS OF COMBINING POSTHARVEST CALCIUM AND HEAT TREATMENT ON REDUCING DECAY AND MAINTAINING QUALITY IN APPLES

William S. Conway[1]*, Carl E. Sams[2], Chien Yi Wang[3], and Judith A. Abbott[4], Hort Crops Quality Lab[1,3], Beltsville, MD 20705, Univ. of Tennessee[2], Knoxville, TN, 37996, and Instr. Sensing Lab[4], Beltsville, MD, 20705.

Heat treatment of 'Golden Delicious' apples (*Malus domestica* Borkh) at 38C for 4 days, pressure infiltration with 2 or 4% solutions of $CaCl_2$, or a combination of both with heat following $CaCl_2$ treatment affected both decay and firmness during 6 months storage at 0C. The heat treatment alone reduced decay caused by *B. cinerea* by about 30%, while heat in combination with a 2% $CaCl_2$ solution reduced decay by about 60%. $CaCl_2$ solutions of 2 or 4% alone reduced decay by 40% and 60%, respectively. Heat treatments, either alone or in combination with $CaCl_2$ treatments, best maintained firmness (80 N), followed by fruit infiltrated with 2 or 4% solutions of $CaCl_2$ alone (70 N) and then the nontreated controls (66 N). Instron Magness-Taylor and Instron Compression Test curves show that heat treated fruit differed qualitatively and quantitatively from nonheated fruit. A combination of heat treatment after $CaCl_2$ infiltration increased surface injury over those fruit heated or infiltrated with $CaCl_2$ solutions alone.

928 (PS 15)

PURIFICATION AND CHARACTERIZATION OF *N*-ACETYL-β-D-GLUCOSAMINIDASE FROM 'GOLDEN DELICIOUS' APPLES.

Seong Yong Choi* and Kenneth C. Gross, USDA/ARS, Horticultural Crops Quality Laboratory, Beltsville MD 20705 (KCG, SYC) and Kyungbuk Rural Development Administration, Taegu, Korea (SYC)

The ripening-related biological activity (Priem and Gross, 1992, *Plant Physiol* 98:399-401) of free *N*-glycans in fruit was recently reported. Thus, enzymes involved in *N*-glycan metabolism may be important in understanding the regulation of ripening. *N*-acetyl-β-D-glucosaminidase (EC 3.2.1.30) was purified to homogeneity and characterized from climacteric 'Golden Delicious' apple (*Malus domestica* Borkh.) fruit tissue. This enzyme cleaves terminal *N*-acetylglucosaminyl residues from the non-reducing end of glycans. The enzyme was extracted in 25 mM Na-acetate (pH 5.0) containing 2% PVP, 0.1 mM EDTA, and 0.5 mM DTT. Activity was 0.02 μmol/min/gfw in the crude extract. Ammonium sulfate fractionation (30 to 70%), Mono-Q FPLC and Con A-Sepharose 4B resulted in a 4.7% yield and 923-fold purification. The enzyme had a $K_m$ for *p*-nitrophenyl-*N*-acetyl-β-D-glucosaminide of 136 μM. Optimal pH and substrate concentration were 6.0 and 0.5 mM, respectively. Activity was inhibited at substrate concentrations above 0.5 mM. The molecular weight of the enzyme was estimated to be 29 kD using SDS-PAGE.

929 (PS 15)

**REDUCTION IN ETHYLENE PRODUCTION INDUCED BY POSTHARVEST HEAT TREATMENT OCCURS WITHOUT AN APPARENT DECREASE IN ETHYLENE-FORMING ENZYME ACTIVITY**

Joseph L. Forcherio*, Carl E. Sams, Dept. of Plant and Soil Science, The Univ. of Tennessee, Knoxville, TN 37901, and William S. Conway, Horticulture Crops Quality Lab, Agricultural Research Service, U.S.D.A., Beltsville, MD 20705.

Apples (*Malus domestica* Borkh cv. 'Delicious') were stored after harvest for 2 weeks at 0 C. Fifteen fruit (5 fruit per replication, 3 replications) were then removed from storage and heated (38 C, 3 days) and 15 fruit remained in storage (control). After treatment the fruit were returned to storage for 2 months at 0 C. The fruit were then removed from storage and assayed for 1-aminocyclopropane-1-carboxylic acid (ACC) activity and ethylene production. The ability of the fruit tissue to convert ACC to ethylene was also determined by utilizing ACC spiked samples. Heat significantly lowered the ethylene production rate. However, the conversion of ACC to ethylene was not different between treatments when samples were spiked with 1 μM of ACC. This indicates that ethylene forming enzyme (EFE) activity was not affected by the heat treatment. The effect of heat treatment on ACC concentration and the conjugation of ACC into 1-malonylaminocyclopropane-1-carboxylic acid (MACC) will be discussed.

930 (PS 15)

EFFECT OF HARVEST DATE AND RELATIVE HUMIDITY AFTER HARVEST ON RIPENING OF 'LA FRANCE' PEAR FRUITS.

Hideki Murayama*, Toshikazu Koyama, Miwa Onta and Tadaaki Fukushima, Department of Bioproductin, Faculty of Agriculture, Yamagata University,Tsuruoka, 997 Japan

'La France' pear fruits were harvested at weekly intervals for a 3-week period beginning Oct. 8, 1992, 1 week before commercial harvest. On the next day, fruits were stored at 20°C and 55%, 75% or 95% relative humidity (RH). Ethylene production, respiration rate and flesh firmness were determined at harvest and after intervals of storage. Early-harvested fruits at 55% RH showed greater flesh firmness than those at 75% and 95% RH on and after 37 days. Some fruits failed to ripen and never softened appreciably. Except for those, all fruits ripened fully, but early-harvested fruits required more than 2 weeks to ripen than optimum- and late-harvested fruits. Ethylene production reached maximum on day 17 and day 13 in optimum- and late-harvested fruits, respectively. Conversely, ethylene production and respiration rate remained low over 41 days in early-harvested fruits, especially those at 55% RH. In optimum- and late-harvested fruits, the rate of softening, ethylene production and respiration rate were not affected by different RH.

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931 (PS 15)

CHARACTERIZATION OF $Ca^{2+}$-TRANSLOCATING ATPase FROM PLASMA MEMBRANE VESICLES OF SOUR CHERRIES

W.F. Campbell* and J.L. Anderson, Plants, Soils, and Biometeorology Dept., Utah State University, Logan, UT 84322-4820

Calcium maintains plasma membrane integrity, osmoregulation and extends the quality of shelf-life of sour cherry, *Prunus cerasus* L., fruit. Cherry fruit clusters were sprayed with Calcium Metalosate [an amino acid calcium chelate (AACa), Albion Labs, Inc., Clearfield, UT] solution. AACa-treated and untreated cherries were hand-harvested and placed in plastic bags. For comparison of Ca compounds, hand-harvested cherries were placed in cold tap water or 2% calcium chloride ($CaCl_2$). All cherry samples were transported on ice to the lab, stored at 4°C for 24-48 h, and processed for membrane-enriched vesicle fractions. Membrane protein content was about 4-fold greater in Ca-treated fruit than in controls. $^{45}Ca^{2+}$ uptake by the vesicles was ATP-dependent with the radiotracer accumulated by the vesicles being released when the calcium ionophore A23187 was added. ATPase activity and $H^+$-pumping were both completely inhibited by orthovanadate, suggesting that the fractions were free from non-plasma membrane ATPases. Because $CaCl_2$ is caustic and causes corrosion of equipment, our results suggest that spraying AACa may offer an alternative application of Ca.

932 (PS 15)

EFFECT OF IRRIGATION REGIMES ON O'HENRY PEACH (*Prunus persica* L. BASH) FRUIT QUALITY AND STORAGE PERFORMANCE

Carlos H. Crisosto, R. Scott Johnson, Juvenal G. Luza and Gayle M. Crisosto, Department of Pomology, University of California, Kearney Agricultural Center, Parlier, CA 93648 USA

Water used for peach irrigation can be reduced by supplying less than full evapotranspiration (ET) during a specific period of fruit growth (RDI). The effect of RDI technique of fruit quality, internal breakdown and storage performance was studied on 'O'Henry' during the 1990, 1991 and 1992 seasons. The three irrigation regimes (50, 100 and 150% ET) imposed during the three seasons induced a higher soluble solids content in the fruit without reduction of postharvest life. Scanning and light microscope observations indicated a modification of cuticle and epidermal characteristics by the three irrigation treatments. These differences in exodermis structure may explain the lower percentage of water loss on fruit from the under irrigated (50% ET) compared to well irrigated (100% ET) and over irrigated (150% ET) treatments during the three seasons.

933 (PS 15)

**NONDESTRUCTIVE PEACH FRUIT FIRMNESS DETERMINATION USING SONIC IMPULSE**

Niels O. Maness*, Department of Horticulture and L. A., and D. Chen and Marvin L. Stone, Department of Agricultural Engineering, Oklahoma State University, Stillwater, OK 74078.

Sonic impulse parameters related to peach fruit firmness were identified. Fruit were harvested at threshold mature, mature firm, firm ripe and soft ripe stages of development, and impulse spectra were obtained at labeled locations from opposite cheeks of each fruit after harvest and at intervals during storage at 20 C. A subset of fruit were sacrificed after each impulse sampling period for destructive firmness determination at the labeled sonic impulse sites using an Effegi penetrometer with a standard 11 mm probe. Sonic resonant frequencies were positively correlated with destructive fruit firmness measurements, and decreased as fruit firmness decreased. Multiple regression equations including sonic impulse data and storage time were developed to predict average fruit firmness for the cultivars studied. Supported by OCAST (Oklahoma Center for the Advancement of Science and Technology) grant AR2-069 and the Oklahoma Agricultural Experiment Station.

934 (PS 15)

RASPBERRY FRUIT POSTHARVEST BIOCONTROL AND PACKAGING

V.M.Guerrero*, R.D.Berghage, M.M.Wall, C.L.Biles, C.M.Liddell. New Mexico State University. Las Cruces, N.M. 88003.

Studies were conducted with raspberry fruit to isolate and identify naturally occurring yeasts for possible biological control activity against postharvest fungi. The yeasts identified were heterothallic or asexual Ascomycetes and Basidiomycetes. Biocontrol activity was compared with an isolate of *Pichia guillermondi* and a water-treated control. After 16 days at 4C, 30% of the water-treated fruit were diseased, while there was no disease on fruit treated with *Pichia sp.* or one of the collected yeasts. Treated raspberry fruits were packaged in heat-sealed low density polyethylene bags and evaluated for % soluble solids, pH and internal gas concentrations as well as disease incidence. After 14 days in storage the fruit started to develop off-flavors. Soluble solids and pH did not change. Disease incidence increased as storage time increased. The yeasts collected and the *Pichia sp.* isolate showed potential as biocontrol agents for reducing disease in packaged raspberries.

935 (PS 15)

POSTHARVEST RESPONSE OF BLUEBERRIES AFTER LOW-DOSE IRRADIATION

William R. Miller* and Roy E. McDonald, USDA, ARS, U.S. Horticultural Research Laboratory, 2120 Camden Road, Orlando, FL 32803

Fruit of 'Climax' rabbiteye blueberries (Vaccinium ashei Reade) were exposed to relatively low energy dosages of gamma or electron irradiation ranging from 0.25 to 3.0 kGy, and evaluated after various storage regimes to determine threshold levels of physiological and physical tolerance of treatment. Dosages above 1.0 kGy seriously affected berry firmness, acceptability of flavor, and texture. Electrolyte leakage, skin color, total soluble solids, acidity, and pH were not affected by dosages from 0.25 to 1.0 kGy. There was no evidence of loss of pectin as dosage increased, but decreased berry firmness indicated loss of structural integrity of the cell wall. Berry weight loss averaged 4.0% after 14 days storage at 1C plus 2 days at 15C and was not affected by dosage. Irradiation of blueberries at 0.75 to 1.0 kGy may be a feasible quarantine treatment for blueberry pests.

936 (PS 15)

FRUIT PRODUCTION POTENTIAL OF SEVERAL ACTINIDIA SPECIES UNDER NORTH ALABAMA CONDITIONS

Caula A. Beyl and Kenneth W. Creel*. Department of Plant and Soil Science, Alabama A&M University, Normal, AL 35762

To characterize their fruit production potential under north Alabama conditions, one-year old plants of six species of Actinidia were established in 1988 in a replicated planting at the Pomology Research Orchard in Huntsville, AL. Several of the *Actinidia* species fruited for the first time in 1991 including: *A. deliciosa, A. arguta* 'Ananasnaja', *A. arguta x melanandra, A. melanandra, A. arguta cordifolia, and A. polygama.* Beginning in early August and continuing until late September fruit length, fruit width, % soluble solids, fruit firmness, and fresh weight were evaluated at ten day intervals. Total number of fruit produced and the number dropped were counted initially. Preliminary subjective taste evaluations were done throughout the time period. There was substantial fruit drop, particularly on *A. melanandra.* Values for mean percent soluble solids measured in late September for *A. arguta* 'Ananasnaja' ranged from 7.3-11.0%. Fruit drop was a problem for *A. melanandra* with slightly over 50% of the fruit having dropped by early August. *A. arguta* 'Ananasnaja' produced the most abundant initial fruit crop and had the most desirable fruit from the standpoint of flavor.

937 (PS 15)

LOW-TEMPERATURE SCANNING ELECTRON MICROSCOPY: A PROMISING TECHNIQUE FOR EXAMINING HORTICULTURAL TISSUE

Stephane Roy[1]*, William S. Conway[1], Alley E. Watada[1], Eric F. Erbe[2] and William P. Wergin[2], Hort Crops Quality Lab[1], Electron Microscopy Lab[2], USDA, ARS, Beltsville, MD 20705

Conventional scanning electron microscope (SEM) have greatly expanded our knowledge about the ultrastructure of plant tissues; however, the fixation, dehydration and drying procedures required for SEM preparation of specimens, are slow, extract soluble materials and cause shrinkage. Recent

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improvements in a technique referred to as low temperature (LT) SEM now allow samples to be observed in a frozen hydrated state, thereby avoiding the artifacts associated with conventional specimen preparation. To evaluate this technique, healthy and Botrytis cinerea infected 'Golden Delicious' apple fruit were collected, frozen in liquid nitrogen, examined and photographed in a Hitachi S-4100 SEM equipped with and Oxford CT 1500 Cryotrans System. Results indicated that LT SEM (1) retained soluble materials such as platelets of the epicuticular wax; (2) preserved tissues in varying degrees of hydration and (3) maintained loosely associated structures such as spores and hyphae. These results suggest that LT SEM has potential applications to many horticultural problems.

938 (PS 15)

LONG TERM EFFECTS WHEN BENZYLADENINE IS USED REPEATEDLY AS A CHEMICAL THINNER ON MCINTOSH APPLES

Duane W. Greene, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

The long term effects of benzyladenine (BA) were assessed when it was applied as a chemical thinner to the same mature McIntosh trees for four consecutive years 0, 50, or 100 mg·liter$^{-1}$. NAA at 6 mg·liter$^{-1}$ was used each year as the standard thinning treatment. BA and NAA thinned comparably in most years. BA frequently increased fruit size more than NAA at comparable crop loads. When BA was applied at temperatures above 30°, spur elongation was noted, and flower bud the following year were smaller. BA reduced seed number in some years. It had no adverse effects on postharvest storage life of treated apples that could not be explained directly by increased fruit size due to thinning. BA appears to be a promising chemical thinner for use on McIntosh apples.

939 (PS 15)

LONG-TERM EFFECTS OF PLANT GROWTH REGULATORS ON TISSUE-CULTURED APPLE TREES

Richard H. Zimmerman* and George L. Steffens, USDA-ARS-Fruit Laboratory, Beltsville, MD 20705

Tissue-cultured (TC) own-rooted 'Gala' and 'Triple Red Delicious' apple (*Malus domestica* Borkh.) trees, planted at three different spacings (1121, 747 and 561 trees per hectare) and treated with the plant growth regulators alar plus ethrel, paclobutrazol or uniconazole using several application techniques, were evaluated for a total of 9 years in the orchard. Cumulative yields did not differ between TC and budded (on M.7a) controls, although the budded trees had larger yields for the first 2 ('Gala') or 3 ('Triple Red Delicious') years of the 7 seasons in which fruit were harvested; yields from trees treated with alar-ethrel were significantly larger than for budded controls but did not differ from the TC controls. Uniconazole spray applications had an earlier and more consistent effect on fruit yield than any other uniconazole or paclobutrazol treatment, although cumulative yields were not as great as for alar-ethrel treated or TC control trees, but were equal to the budded control trees. The alar-ethrel combination had less effect on tree size control than most of the paclobutrazol and uniconazole treatments. Trees of 'Gala' bloomed and fruited earlier than those of 'Triple Red Delicious' and had significantly higher yields.

940 (PS 15)

CALCIUM LEVELS IN APPLE SEEDLINGS AND FRUIT FOLLOWING NAA AND TIBA TREATMENTS

Wol Soo Kim* and George C. Martin, Department of Pomology, University of California, Davis, CA 95616-8683 USA

Foliar sprays of TIBA inhibited the growth of apple seedlings, and induced bitter pit of field grown 'Golden Delicious' fruit. Total Ca levels were significantly decreased in the stems and leaves of apple seedlings, and in fruit peel. Foliar sprays of NAA increased total Ca content in shoots of apple seedlings. The Ca levels in the roots of seedlings were affected less by TIBA and/or NAA sprays than that of shoots. Irrigation after TIBA treatment inhibited apple seedling growth, and decreased total Ca content in shoots and roots, while NAA increased the growth and Ca content in the seedlings. TIBA via lanolin mixture to the shoot inhibited growth, and decreased the Ca content in shoots and roots of apple seedlings. NAA via lanolin mixture did not affect growth, whereas it increased the Ca content in the shoots of apple seedlings.

941 (PS 15)

THINNING OF "EMPIRE" APPLE WITH BENZYLADENINE

V.E. Emongor, J.T.A. Proctor, E.C. Lougheed and D.P. Murr. Horticultural Science Department, University of Guelph, Guelph, Ontario. N1G 2W1, Canada.

In a two-year trial using mature Empire/M.27 apple trees, application of 100 or 200 mg.l$^{-1}$ benzyladenine (BA) as dilute sprays 16 or 22 days after full bloom (DAFB) thinned to 6 or 5 fruit cm$^{-1}$ limb circumference. BA reduced fruit set by 50% and proportionately increased trunk cross-sectional area growth. BA increased return bloom, total shoot growth and shoot number cm$^{-1}$ limb circumference, but decreased mean shoot length. At harvest, fruit from thinned trees were significantly greater in weight, diameter, length and L/D ratio, but fruit colour and harvest maturity was unaffected. Firmness and soluble solids (TSS) of fruit from thinned trees were higher than control at harvest and following storage at 0-0.5°C and 90-95% RH. BA-treated fruit exhibited reduced respiration rate and ethylene production, and exhibited no storage disorders.

Application of 500 or 1000 mg l$^{-1}$ BA 4 weeks before harvest to mature Empire and McIntosh/M.27 apple trees was performed to determine if late BA application could reduce the loss of fruit firmness that occurs upon storage, especially in McIntosh. BA-treated fruit of both cultivars, were firmer at harvest and following storage in air for up to 4 months. Fruit TSS were unaffected.

942 (PS 15)

PEACH PISTIL RESPONSES TO MULTIPLE FALL ETHEPHON APPLICATIONS

Edward F. Durner, Rutgers Fruit Research Center, RD 2 Box 38, Cream Ridge, NJ 08514

Ethephon (100 mg•liter$^{-1}$) was applied to mature peach trees [*Prunus persica* (L.) Batsch. cv Jerseydawn] on 1, 2, 3 or 4 dates beginning 15 Sept. 1990 at approximately 2 week intervals for a total of 12 treatments. Ethylene evolution from flower buds and flower bud phenology were monitored through bloom the following spring. Total flower bud density, live flower bud density, percentage live pistils, yield and number of fruit per tree were also measured. The response to multiple ethephon applications was greatly influenced by the timing of specific treatment combinations rather than by the total amount of ethephon applied over the course of the experiment. Ethylene evolution was elevated for about 2 weeks following application(s), however, no clear relationships between bud phenology or survival and ethylene evolution was observed. Several of the multiple ethephon applications significantly delayed bloom to the 75% pink stage, however, none of the treatments significantly influenced development to 75% balloon or fully open stages. Several of the multiple applications caused significant pistil mortality.

943 (PS 15)

EFFECT OF ETHEPHON ON BLOOM DELAY IN ALMOND TREES.

Raúl Leonel Grijalva-Contreras, Gerardo Martínez-Díaz* and Fabián Robles-Contreras, INIFAP-CIANO. Apartado Postal 125, Caborca, Sonora, México. 83600.

Under temperate climates almond production is restricted to areas without risk of frosts on flowering. However an artificial delay of flowering would be beneficial to avoid frost damages under such conditions. With the objetive of delay flowering, foliar applications of Ethephon were made to mature almond trees in the fall 1990 and 1991, when their natural defoliation was 10%. Three rates of Ethephon and a check were evaluated for that proposal. Bloom delay was 7, 8 and 9 days for 75, 150 and 300 mg.L$^{-1}$ in the first year the three rates decreased fruit set and fruit yield. In the second year of evaluation the bloom was delayed only 3 days at the highest rate but fruit set and fruit yield was not affected. In both years fruit quality was the same for all the treatment.

944 (PS 15)

BERRY & JUICE QUALITY RESPONSE TO CANOPY MANAGEMENT & ETHEPHON IN 'RELIANCE' TABLE GRAPES

John Fitzgerald & W. Keith Patterson*, Department of Horticulture & Forestry, University of Arkansas, Fayetteville, AR 72701

Grape clusters were subjected to one of two levels of leaf removal, one of two levels of preharvest ethephon spray, and either thinned to a basal cluster or left unthinned. Ethephon was applied at a concentration of 100 ppm two weeks after veraison. Affects on soluble solids content (SSC), titratable acidity (TA), pH, hue, chroma,



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and L, a, b values were not consistent. In 1989, light exposed clusters of thinned vines had significantly higher SSC. In 1990, when ethephon was applied to non-thinned vines, light-exposed clusters had higher SSC values than non-exposed clusters. Light, ethephon, or thinning in 1989 and light or ethephon in 1990 significantly increased TA. Ethephon in 1989 and light in 1990 significantly higher pH in 1989, and ethephon-treated clusters from thinned vines had significantly lower pH in 1990. Juice from light treatments in 1990 had significantly higher L, a, b, and chroma values. Ethephon significantly increased the "a" value of juice in 1989, and light significantly increased the "b" value. Hue was significantly different for light and ethephon treatments in 1989.

945 (PS 16)

GREENHOUSE INTEGRATED PEST MANAGEMENT PROGRAM

Sharon L. von Broembsen and Michael A. Schnelle*, Depts. of Plant Pathology and Horticulture and Landscape Architecture, Oklahoma State University, Stillwater, OK 74078-0511

A complete program of integrated pest management (IPM) for commercial greenhouse production was developed. Comprehensive educational materials in the form of fact sheets, guidelines, action checklists, bulletins and a regular newsletter were produced to aid commercial greenhouse growers in Oklahoma. This literature was also used to supplement two intensive IPM workshops provided statewide to Oklahoma growers, educators and cooperative extension agents. In addition to written materials, two satellite videoconferences were conducted for the benefit of county extension agents and their clientele across the state and throughout the U.S., where compatible down-link facilities existed. Videotapes were prepared from the videoconferences for the benefit of growers and cooperative extension agents who lacked access to down-link satellite technology or desired a record for later study. A detailed implementation guide with support materials is available for initiation of a greenhouse IPM program for any state. Very few modifications if any would be necessary to adopt the OSU program.

946 (PS 16)

NUCLEAR MAGNETIC RESONANCE IMAGING OF STRAWBERRY FRUIT

John L. Maas*, Merle M. Millard, Michael J. Line, and Gene J. Galletta, United States Dept. of Agriculture, Beltsville, Maryland 20705

Strawberry fruit were non-destructively examined by spin-echo nuclear magnetic resonance imaging (NMRI) to determine internal structure, proton (water) density and T2 proton relaxation times of healthy fruit in order to determine physical and water density and water binding changes due to injury and fungal infection. Detached strawberry flower buds prior to anthesis, anthesis, developing receptacles, and fruit from green, white, to red-ripe stages were examined to determine variations in normal fruit. Fruit rots caused by *Botrytis cinerea, Hainesia lythri*, and *Colletotrichum acutatum* were compared. *B. cinerea* causes a watery rot that occurs as a uniform gradient from infected to healthy tissue, whereas *C. acutatum* causes a dry rot with an indistinct border between healthy and infected tissue. *H. lythri*, on the other hand, causes a rot that forms a distinct and disparate boundary between the advancing infection and healthy tissue; the infected portion of the fruit may be extracted as a mass of hyphae and fruit tissue that retains its shape. NMRI may be a useful tool for identifying enzyme systems of pathogens involved in fruit decay.

947 (PS 16)

ACQUIRED DISEASE RESISTANCE TO ANGULAR LEAF SPOT (PSEUDOMONAS SYRINGAE CV. LACHRYMANS) IN CUCUMBER

L. Newell, I.E. Widders* and R. Hammerschmidt, Department of Horticulture and Botany and Plant Pathology, Michigan State University, East Lansing, MI 48824

Resistance to fungal and bacterial pathogens can be induced in cucurbit crops by limited inoculation of young plants with necrosis inducing pathogens or by treatment with certain salt solutions. In greenhouse experiments with pickling cucumber (cv. Flurry), foliar applications of 2,6-dichloroisonicotinic acid (CGA-41396; Ciba Geigy) to seedlings enhanced both acid peroxidase activity and reduced the number of lesions per leaf in a dose dependent manner following a challenge inoculation. Maximum response was obtained with 20-30 mg a.i./L CGA 41396 treatment. Soil drenches were equally effective in inducing resistance. Under field conditions, multiple foliar applications of 35 mg a.i./L of CGA 41396 prior to flowering reduced the incidence of angular leaf spot lesions by >70% on leaves at harvest. Pickling cucumber fruit yields were significantly lower in controls than in CGA treatments due to disease pressure.

948 (PS 16)

EFFECTS OF REDUCING PESTICIDE RATES ON TRELLISED APPLES

R. M. Crassweller*, T. C. Clark, J. W. Travis, and E. G. Rajotte, The College of Agricultural Sciences, The Pennsylvania State University, University Park, PA 16802

Chemical rates for commercial apple orchards are derived from replicated single-tree spray studies based upon dilute (>3740 l/ha) amounts of carrier to standard trees and are not adjusted to tree size. The purpose of this study was to evaluate a season long pest management program where rates had been reduced to 60% of standard recommended rates on trellised apple trees. The experimental unit consisted of 4 trellised rows of apples planted in 1976. The cultivars in the study were 'McIntosh', Golden Delicious, and spur and nonspur 'Delicious'. Treatments were full rate (100), 60% of the full rate (60) and a control (0). Disease and insects damage was monitored periodically throughout the season and damage was assessed at harvest on the spur 'Delicious' and 'Golden Delicious' fruit. During the experiment it was discovered that the orchard used had developed resistance to benomyl resulting in some apple scab present even in the 100 treatment. There was a reduction in the level of scab however in the 60 and the 100 trt compared to the 0 trt. At harvest the major diseases observed in the 0 trt blocks was sooty blotch and flyspeck. Insect damage was minimal. Results from the study suggest that pesticide rates may be reduced by 40% with little impact upon fruit quality.

949 (PS 16)

**$C_6$ AND $C_9$ ALDEHYDES PRODUCED BY THE LIPOXYGENASE PATHWAY INHIBIT FUNGI PATHOGENIC ON BROAD BEAN**

Steven F. Vaughn and Harold W. Gardner, USDA, Agricultural Research Service, National Center for Agricultural Utilization Research, Peoria, IL 61604

Several unsaturated $C_6$ and $C_9$ aldehydes are released by broad bean (*Vicia faba* L.) tissues when wounded mechanically or by pathogens via lipoxygenase-catalyzed lipid oxidation. We examined the growth of isolated fungal cultures of the broad bean pathogens *Colletotrichum truncatum, Rhizoctonia solani* and *Sclerotium rolfsii* when exposed to several of these aldehydes. *(2E)*-Hexenal, *(2E)*-nonenal and *(3Z)*-nonenal were inhibitory to the growth of *R. solani* and *S. rolfsii* at 0.004 ul/ml or greater when applied as volatiles, although higher levels were required to inhibit *C. truncatum*. When applied directly in the growth medium, *(2E)*-4-hydroxy-2-nonenal was the most inhibitory compound tested, even though it had the least effect as a volatile.

950 (PS 16)

**TRANSMISSION OF PHYTOPHTHORA PARASITICA IN AN EBB AND FLOW SUBIRRIGATION SYSTEM**

Stephen S. Strong*[1], C. Fred Deneke[1], Kira L. Bowen[2], Bridget K. Behe[1], and Gary J. Keever[1], [1] Department of Horticulture, and [2] Department of Plant Pathology, Auburn University, Auburn, AL 36849.

The root rot fungus *Phytophthora parasitica* is known to be very destructive to annual vinca (*Catharanthus roseus*). *Phytophthora* produces motile zoospores which swim freely in water, posing a special threat to crops grown using a recirculating water supply. Vinca were transplanted into 7 cm square pots containing a sphagnum peat:perlite medium. The medium was inoculated with the pathogen and plants were then placed in one row on each ebb and flow bench. Untreated vinca were placed in six additional rows on the benches. Separate benches were used to space plants at a distance of either 1 cm or 4 cm between pots. Plants were harvested biweekly over a six week period and tested for presence of *Phytophthora*. Cumulative results of root sampling revealed pathogen movement to 60% of untreated plants spaced at 1 cm, and to 30% of those spaced at 4 cm. Severe root injury (injury to root system ≥ 25%) was exhibited in 36% of the closer spaced plants, compared to 13% of those spaced at 4 cm. *Phytophthora* zoospores were detected in one tank which was used to irrigate plants spaced at 1 cm. Closer plant spacing enhanced the pathogen's ability to infect healthy plants.



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951 (PS 16)

DOWNY MILDEW CONTROL IN GRAPES WITH METALAXYL

J. D. Abbott*

CIBA-GEIGY Corp., Agricultural Division, PO Box 18300, Greensboro, NC 27419-8300.

Downy mildew (Plasmopara viticola Berk. & Curt.) is a major disease in humid grape-growing areas potentially resulting in major crop loss. Tests were conducted in PA from 1990-1992 in two commercial vineyards to evaluate crop safety and downy mildew control in grapes (Vitis sp. L.) with two metalaxyl-containing formulations compared to a standard program and untreated check. Four applications were made at 7-15 day intervals beginning when the shoots were 15-25 cm long using a handgun set to deliver 1870 l ha-1. In 1990, Ridomil MZ58WP (2.2 kg ha-1) applied prebloom followed by Ridomil Copper 70WP (1.1-2.2 kg ha-1) post bloom provided excellent control of downy mildew compared to Nova 40WP + mancozeb 80WP (0.28+3.3 kg ha-1). Twenty-four days after the last application, disease incidence and severity on the leaves was 100 and 67% in the check plants, respectively. The Ridomil-treated plants ranged from 6.7-16.7% and 1.7-10.7% while the Nova+mancozeb-treated plants had 26.7 and 20% disease incidence and severity, respectively. The untreated check had 63% of its fruit infected compared to <1% in the Ridomil-treated and 6.7% in the Nova+mancozeb-treated plants. In 1991, no disease developed and disease control results in 1992 were similar to those observed in 1990. Little to no crop injury was observed in tests conducted from 1990-1992 on both copper-sensitive and copper-tolerant varieties.

952 (PS 16)

GENOTYPIC VARIATION OF LIPOXYGENASE/LYASE-DERIVED VOLATILE PRODUCTION BY *FRAGARIA* SPECIES

S.S. McDonald, T.R. Hamilton-Kemp, and D.D. Archbold, Dept. of Horticulture and L.A., University of Kentucky, Lexington, KY 40546-0091

Products of the lipoxygenase/lyase (LOX) pathway such as hexanal, *c*-3-hexenal, and *t*-2-hexenal may promote plant pest resistance. The objective of this study was to screen for differences in LOX products among 5 *Fragaria* species, two selections from each. Volatiles produced upon freezing/thawing leaf disks were measured by capillary GC using a direct headspace sampling technique. The primary volatiles produced were hexanal, *c*-3-hexenal, and *t*-2-hexenal. The total yield of each compound and their relative proportions varied among selections. The highest individual yields for hexanal, *c*-3-hexenal, and *t*-2-hexenal were observed in *F. vesca*, *F. virginiana*, and *F. virginiana glauca*, respectively. The greatest variation in relative proportion was with *c*-3-hexenal which ranged from 35% of the total yield in a selection of *F. virginiana* to 6% in a selection of *F. chiloensis*. This same selection of *F. chiloensis* also had the lowest total yield of *c*-3-hexenal, approximately 25% of the average yield of this compound. *F. xananassa* produced intermediate yields of the compounds. *t*-2-Hexenal typically contributed 40-50% of the total yield of each of the screened selections .

953 (PS 16)

INVESTIGATIONS OF THE ROLE OF EPICUTICULAR WAX IN RESISTANCE OF GRAPE BERRIES TO *BOTRYTIS CINEREA*

Edward W. Hellman*, Department of Horticulture, Forestry and Recreation Resources, Kansas State University, Manhattan, KS 66506

Prior to inoculation with a spore suspension of *Botrytis cinerea*, detached mature grape berries were given treatments to disrupt the epicuticular wax; gently rubbing with a rounded spatula, rubbing with a tissue, dipping in chloroform for 10 sec., or wounding with a scalpel. Other berries were inoculated at undisturbed areas on the side of the berry and at the base of the pedicle, or at the base of a pedicle with a natural wound. Berries were incubated at 23°C with 99% relative humidity for 72 hours, then evaluated for infection.

Berries of *Vitis vinifera* cultivars 'Thompson Seedless' and 'Perlette' had infection rates of 18.5% and 3%, respectively, when the wax was undisturbed. Infection rates of berries with disrupted wax or natural wounds were much higher for both cultivars, ranging from 20% to 100%. No infections occured on either treated or untreated berries of cultivars derived from *V. aestivalis*, 'Cynthiana'; *V. labruscana*, 'Concord'; or those of hybrid origin, 'Mars' and 'Vignoles'. Wounding berries of 'Concord' and 'Cynthiana' resulted in 60% infection rates.

954 (PS 16)

VEGETABLE OIL APPLICATIONS CONTROL SCALE INSECTS ON DORMANT APPLE AND PEACH TREES.

C.D. Pless*, Entomology and Plant Pathology Department, D.E. Deyton, and C. E. Sams, Department of Plant and Soil Science, University of Tennessee, Knoxville TN 37901-1071.

Twigs from peach trees heavily infested with terrapin scale (*Lecanium nigrofasciatum)* and from apple trees heavily infested with San Jose scale (*Quadraspidiotus perniciosus)* were collected in January 1993. The twigs (10 replications) received no treatment (control) or dips for 1 second in 2.5 or 5.0% petroleum (dormant) oil (PO), 2.5, 5.0, or 7.5% soybean oil (SO), 5.0% corn oil (CO), 5.0% canola oil (CAO), or 0.6% Latron AG44M emulsifier. All vegetable oil treatments contained 0.6% Latron AG44M. After 2 weeks, mortalities of San Jose scale on apple ("blackcap" stage, 10 per twig) and terrapin scale on peach (mean of 36 scale insects per twig) were visually determined. Approximately 2% of the terrapin scale and 6% of San Jose scale on control twigs were dead at time of evaluation. Twigs treated with 2.5 or 5.0% PO had 76 or 97% mortality of terrapin scale on peach, respectively. Twigs dipped in 5% SO, CO, or CAO had 89%, 88%, and 96% mortality of terrapin scale . On apple, twigs dipped in 5% SO, CO, or CAO had 98, 100, and 100% mortality of San Jose scale, respectively, compared to 94% mortality for the 5.0% PO treatment.

955 (PS 1)

STRUCTURAL CHANGES IN PERISPERM TISSUE DURING MUSKMELON SEED GERMINATION

Wangechi Muthui* and Gregory E. Welbaum, Department of Horticulture, VPI & SU, Blacksburg, VA 24061-0327.

Muskmelon (*Cucumis melo* L.) embryos are enclosed in an envelope consisting of a single layer of residual endosperm and a 2- to 4-cell-layered perisperm. The perisperm envelope (endosperm + perisperm) provides a barrier to radicle elongation. The structure of the perisperm envelope adjacent to the radicle tip was examined using scanning electron microscopy 10, 15, 20, and 25 hours from the start of imbibition in water on germination blotter paper at 25°C. Seeds were frozen in liquid nitrogen and the cone of the perisperm envelope tissue surrounding the embryo was removed. Perisperm cones were mounted on aluminum stubs and coated with gold. At 10 hours after the start of imbibition, there were no visible changes in the tissue. At 15 hours, small cracks were observed in the walls of the perisperm cone tissue between adjacent cells. At 20 hours, the cracks had expanded and were visible throughout the perisperm cone. At 25 hours, radicle emergence occurred in most seeds, because perisperm cells broke apart along the cell walls at the tip of the perisperm cone. Visible evidence suggests that radicle emergence occurred, not because perisperm cells adjacent to the radicle were crushed under the force of the expanding radicle, but rather by a combination of pressure from the radicle as well as degradation of the perisperm cell wall. This confirms previous indirect evidence, obtained by psychrometry, that showed no increase in radicle turgor during germination. Cell wall degradation in the perisperm tissue precedes radicle growth and is a key event in muskmelon seed germination.

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