

# ABSTRACTS

## Colloquia Workshops Contributed Papers (Oral and Poster)

### 87th 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: 002 (PS II) represents abstract 002 in Poster Session II; 180 (PS VIII) represents abstract 180 in Poster Session VIII.

Abstracts for Oral Sessions, Colloquia, and Workshops are grouped by sessions, which are arranged more or less in numerical sequence 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 Glance charts. The author presenting the paper is indicated by an asterisk.

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#### POSTER SESSIONS I-IX (Abstr. 001-372)

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##### 001 (PS I)

CALCIUM AND UNICONAZOLE APPLICATIONS MODIFY STEM ANATOMY AND FOLIAR AND BRACT CALCIUM LEVELS OF 'V-14 GUTBIER GLORY' POINSETTIAS.

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Poinsettias and other floral crops when treated with the growth retardant uniconazole, Sumagic<sup>™</sup>, are more compact in growth habit. They have also been shown to have reduced stem strength. Calcium applied as a drench has been demonstrated to increase plant height and plant dry weight of poinsettias. Uniconazole reduced plant height without affecting dry weight. Bract color was more intense when calcium was applied as a weekly spray. Poinsettia plants had greater levels of foliar calcium when applied as a drench. Poinsettia plants sprayed and drenched with calcium and treated with uniconazole had greater levels of foliar calcium, however, this was not significantly greater than the control plants treated with uniconazole alone. The lowest level of foliar calcium was observed in uniconazole treated plants where calcium was applied as a spray. Uniconazole applications weakened the stem structure of poinsettias as with other floral crop species.

##### 002 (PS II)

ELONGATION OF LILIUM LONGIFLORUM BUDS AND PEDICELS IS LOCALIZED AT THE BUD BASE REGION

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Success in the production of seasonal flowering plants requires adequate knowledge of plant growth patterns and rates. In Easter lilies, pedicel growth is one of the components of final plant height. Flower bud growth rates are important from the standpoint of timing of anthesis. To learn more about the localization of growth in Easter lily flower buds and pedicels, we conducted a time course experiment. Buds and pedicels were marked at 1.2 mm intervals using an inked bolt. Distances between ink marks were determined at 3 day intervals. Results indicate that 30 mm flower buds elongate almost exclusively from basal regions of the bud. The basal 1.2 mm segment elongated 16 mm in 20 days, while the apical 1.2 mm segment elongated 0.75 mm in the same period. Larger buds (initially 90 mm) gave similar results, although bud tip growth rate increased to some degree just prior to flowering. Pedicel elongation occurred almost exclusively at the apical end of the pedicel, adjacent to the region of greatest bud growth.

##### 003 (PS I)

SOMACLONAL VARIATION IN CUCUMIS SATIVUS L.

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Hybrid seed of cucumber (*Cucumis sativus*) is expensive to produce. Production of 'artificial seeds' through somatic embryogenesis may be a viable alternative. Somatic embryos were induced, multiplied on a semi-solid medium for 8-10 weeks, and germinated on agar-gelled medium before transplanting to soil. It was then important to determine the extent of variation among plants derived from somatic embryos. The criteria for variation among regenerants of cultivar Clinton were: plant height, fruit shape, fruit weight and number (yield/plant), days to first female flower and variation in selected isozymes. All measurements were taken on greenhouse-grown plants. Some regenerants of Clinton were also planted in the field and they flowered and, qualitatively, bore fruit as well as the zygote-derived plants. When quantitative measurements were made, variation was greater than for plants from zygotic embryos, but the visual impact was that there was little variation amongst regenerants. Regenerants grew more slowly and tended to yield higher numbers of slightly smaller fruits than plants from zygotic embryos. Average yield per plant was higher for somatic embryo-derived plants. For cultivar Corona only morphology of plant and fruit was examined. One plant was especially visually mutant and unacceptable as a commercial plant. The defects were readily identifiable in the seedling stage. Preliminary evidence suggests that 'artificial seeds' of cucumbers may be a viable proposition.

## 004 (PS III)

## LEUCOSTOMA TOLERANCE IN PEACH: FUNGAL ISOLATE X PEACH GENOTYPE

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Seven peach clones which were previously identified as resistant, intermediate, or susceptible to *Leucostoma persoonii* were screened against 3 different *L. persoonii* and *L. cincta* isolates to determine if the resistant reaction was fungal species and/or isolate specific. Canker necrotic length varied significantly with the most resistant genotypes; NJ672017002 (1-8) and Yennoh (1-39) having the shortest canker lengths. The virulence of the fungal species and isolates also varied significantly and there was a significant species/isolate x peach genotype interaction. However, this interaction tended to be among the intermediate and susceptible genotypes with the 2 resistant peach genotypes least affected by all isolates.

## 005 (PS VI)

## DIGITAL IMAGE PROCESSING FOR NON-DESTRUCTIVE MEASURES OF WOODY SHRUBS

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For multi-stemmed shrubs, especially those with fine foliage, obtaining measures of leaf area or density of foliage and twigs within the crown may be both difficult and time-consuming. However, this measure may be an indication of the ornamental quality of a species. A method of photographic analysis was developed to perform repeated measures within the crown of woody shrubs. Slides of 5 species of arid land woody shrubs were analyzed by use of a Visual Image Processor system. This digital imaging technique may be applied where comparative measures over time for individual plants is useful. Comparisons were made of slides taken in the fall of 1989 and the spring and fall of 1990. The use of slides limited handling or removal of any portion of the plants. Initial care in slide production and continuity of photographic techniques permits consistent results between measurement dates. This computerized method allows comparative analysis of the growth and "fullness" of plant crowns.

## 006 (PS I)

EFFECTS OF SOIL pH, WATERING RATE, AND SOIL AMENDMENTS ON THE PRODUCTIVITY OF GREENHOUSE-GROWN CHAYOTE (*SECHUM EDULE*)

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Chayote (*Sechium edule* Swartz) is a minor vegetable crop gaining in popularity in the U.S., but with only scant cultural information on it available. The soil pH and water requirements and the effects of various soil amendments on plant productivity were determined in three separate greenhouse pot studies. Chayote plants were grown in either one of eight soil pH levels (5.0 to 6.5), were watered at one of three rates (1.3, 2.5, or 5.0 cm per week), or were planted in one of 16 soil amendment treatments (Oliver silt loam soil or a 1 soil : 1 peat moss (v/v) mix amended with inorganic N-P-K fertilizer, 25 or 50 kg cow or rabbit manure/ha, or 12.5 or 25 kg chicken manure/ha). Data on date of germination, plant height, single and total leaf areas, total plant and separate plant part fresh and dry weights, and presence of flowers were collected. Greatest plant productivity was achieved with a soil pH range of 5.6 to 6.5, a watering rate of 2.5 cm per week, and with several of the soil amendment treatments.

## 007 (PS III)

## RESISTANCE TO BACTERIAL SPOT IN CUCURBITA SPECIES

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No sources of resistance to *Xanthomonas campestris* pv. *cucurbitae* (X.c.c.) in the Cucurbita species have been reported. Cultivars, breeding lines, landraces, and PI lines of 5 Cucurbita species were screened for resistance to X.c.c. in 3 greenhouse tests (GH). A 'florist's frog' was used to inoculate the first fully expanded leaves using a X.c.c. suspension ( $10^7$  CFU/ml). The disease reaction was recorded as the percentage of inoculated leaf area with necrotic lesions

and/or chlorosis. Butternut (BN) breeding lines were also evaluated for reaction to X.c.c. under uniform natural infection in 2 field (F) trials. A randomized complete block design was used in all GH and F experiments. *C. moschata* Nebr. BN PM1-88-8 and *C. martinezii* had high resistance to X.c.c. All other entries in all tests were susceptible. BN PM-88-8 is an early maturing small stable (no crookneck fruit) near-round BN type squash. The fruit are resistant to black-rot, but the leaves are susceptible to powdery mildew. BN PM-88-8 is ideal for microwave cooking because of its near-round shape permitting more uniform cooking. Release is expected in 1990.

## 008 (PS VI)

## ROOT GROWTH OF CHINESE JUNIPER DURING THE FIRST THREE YEARS AFTER PLANTING

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Shoot and root growth were measured on Chinese juniper (*Juniperus chinensis* L.) Var. 'Torulosa', 'Sylvestris', 'Pfitzeriana' and 'Hetzii' 1, 2 and 3 years after planting into a simulated landscape from 10-liter black plastic containers. Mean diameter of the root system increased quadratically averaging 1.2 m/year; whereas, mean branch spread increased at 0.33 m/year. Three years after planting, root spread was 2.75 times branch spread and roots covered an area 5.5 times that covered by the branches. Percentage of total root length located within the dripline of the plants remained fairly constant (71-77%) during the first 3 years following planting. Root length density per unit area increased over time but decreased with distance from the trunk. In the first 2 years after planting shoot weight increased faster than root weight. However, during the third year after planting, the root system increased in mass and size at a faster rate than the shoots. Root length was correlated with root weight within root-diameter classes. Root spread and root area were correlated with trunk area, branch spread and crown area.

## 009 (PS I)

## YIELD AND NITROGEN UPTAKE OF BROCCOLI AND SOIL NITRATE STATUS AS INFLUENCED BY RATE AND TIMING OF NITROGEN APPLICATION

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A Preliminary study conducted in 1985 indicated no significant yield response to 8 treatments ranging in amount of total N applied from 56 to 290 kg N/ha. Treatments in 1986 were as follows: base rate N at 0, 56, 112, and 168 kg N/ha with 0, 1, or 2 sidedressings at 56 kg N/ha each applied at 3 and 6 wks after seeding. Yield differences for base rate N were significant at the first harvest only, while sidedressing effects on yield were significantly different for 3 of the 4 harvests and total yield. Nitrogen uptake during the first 32 days after seeding (DAS) was minimal, 0.17 kg N/ha/day, but increased to 8.05 kg N/ha/day during head formation (55 to 77 DAS). Initial soil nitrate status was high in the top 25 cm (52 kg NO<sub>3</sub>/ha) but decreased to 10.6 kg NO<sub>3</sub>/ha in the control plot by the end of the season. Sidedressings, prior to and during head formation are recommended to maintain an adequate available N supply throughout the growing season.

## 010 (PS III)

GENOTYPIC DIFFERENCES IN MORPHOGENIC POTENTIAL OF CULTURED LEAF EXPLANTS OF *LYCOPERSICON HIRSUTUM*

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Cultured leaf explants obtained from 36 accessions of the wild tomato *Lycopersicon hirsutum* were evaluated for morphogenic capacity in response to 3 cytokinins [zeatin, benzylamino purine (BA) and kinetin] in combination with indoleacetic acid (IAA). Morphogenic responses within this wild species were accession-dependent. Cotyledon tissue, in comparison to true leaf explants, were superior for callus and shoot formation. Optimal callus induction medium varied with accession, but most often contained 13.3 µM BA plus 1.7 µM IAA. Media containing 4.6 or 9.2 µM zeatin plus 0.1 µM IAA were optimal shoot induction media. Explants of *L. hirsutum* f. *typicum* accessions 126445, 127826, 128644, and 390663 and *L. hirsutum* f. *glabratum* accessions 365904, 365905, and 365906 exhibited the highest levels of shoot formation.

011 (PS VI)

NUTRIENT TRANSFER BETWEEN PLANTS THROUGH MYCORRHIZAL HYPHAE  
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Soybean (*Glycine max* (L.) Merr.) and corn (*Zea mays* L.) plants were colonized by vesicular-arbuscular mycorrhizal (VAM) fungi and grown under controlled conditions. Three-part growth containers were used which separated the roots of N-donor (soybean) and N-receiver (corn) plants by screens (40 µm), permeable to VAM hyphae but not to roots. Significant, two-way nutrient transport occurred between plants connected only by the hyphae across a root-free soil bridge. Corn, when associated with nonnodulated, N-fertilized soybean, increased 19% in biomass and 67% in N content relative to similar, but N-deficient associations. Associated with nodulated soybean, there was a 16% decline in P content and a 22% increase in N content in corn. There was a large increase in N transport to the soil (VAM spores and soil mycelia) by the N-fertilized soybeans. If such nutrient fluxes between plants are controlled by source-sink effects, high N concentrations in soybean could account for the N fluxes to corn, and high module P requirement for the reverse flux of P. The results are of consequence for intercrop situations, especially under small-scale management conditions.

012 (PS I)

TRANSPLANT CONDITIONING AND IRRIGATION FOR DESERT CAULIFLOWER STAND ESTABLISHMENT

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Transplant nutrient conditioning for desert cauliflower (*Brassica oleracea* var. *botrytis*) production has enhanced transplant shock recovery, earliness and increased yield; partial defoliation and traditional hardening may also be effective. 'Snowcrown' seedlings fertilized with 50, 150 or 450 mg N l<sup>-1</sup> were clipped to remove 0, 45, 60 or 98% of their leaf area. High root-shoot ratios in the 98% defoliated plants may have resulted in elevated transpiration in new leaves but neither high N conditioning nor defoliation enhanced survival or increased yield. Seedlings raised with 100, 200 or 400 mg N l<sup>-1</sup> were hardened with 4 water/fertilizer withholding regimes prior to transplanting. Non-hardened transplants within each fertilizer regime outyielded hardened transplants. Use of sprinkler or furrow irrigation for day/night establishment of hardened or conditioned transplants will be evaluated.

013 (PS III)

SCREENING FOR ALKALINITY TOLERANCE IN PRUNUS WITH A HIGH CARBONATE SOLUTION

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Peach trees when grown in calcareous soils frequently exhibit lime-induced iron chlorosis. There have been numerous reports of rootstock tolerant to soil alkalinity but given the wide range of field conditions under which the comparison were made, it is difficult to quantify the relative tolerance of the different rootstock. A greenhouse screening procedure using a 0.5g/liter potassium bicarbonate solution (pH 8.0 - 8.3) was employed to compare the tolerance levels of 50 peach, almond and hybrid lines. Most peach lines tested were very susceptible (Nemaguard) to susceptible (Nemared, Lovell). A few exhibited a low level of tolerance (Montclar, Rutger Red Leaf, Rancho Resistant). High levels of tolerance were found with in almond and almond-peach hybrid families.

014 (PS VI)

BIOCHEMICAL CHANGES DURING POLLEN GERMINATION MEASURED BY FTIR SPECTROSCOPY

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A pollen grain undergoes a series of biochemical changes during germination. The

technique of cylindrical internal reflectance FTIR was used to examine spectral frequencies associated with respiration, lipid and protein structure, polysaccharide content, and phosphate-containing metabolizes in pollen from pecan, blue spruce, cattail, and pine. Samples of both pollen and germination medium were analyzed at timed intervals. A microscopic evaluation of percent germination was also made at each sampling time. Preliminary analyses indicate that changes in respiration occur as evidenced by the presence of gaseous CO<sub>2</sub>, and that quantitative changes in lipid and protein occur. FTIR spectroscopy provides a noninvasive method to directly and quantitatively measure metabolic changes associated with pollen germination.

015 (PS I)

ONPLANT: A PRECISION PLANTING MODEL FOR ONIONS

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An interactive computer-based model has been developed to simulate the effects of precision planting onion on quality and yield. Variables used by the model are seed germination, plant survival, planter efficiency, onion growth potential, maximum onion size, sizing potential and inside-outside bed effects. Data bases obtained from 3 onion cultivars were used in the development of the model. The model shows when germination and plant survival are high, single seed drops by the planter results in high yield and large bulbs. At lower germination and survival values, however, a compromise is needed between maximizing yield and obtaining large bulbs.

016 (PS III)

THE EFFECTS OF MILD WINTER WEATHER CONDITIONS ON PEACH FRUIT SHAPE

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Mild winter weather conditions reduce fruit yield and quality of many peach cultivars grown in the Medium Chill Region of the United States. Peach fruit shape instability limits marketing options for growers in this region. The Stonefruit Breeding Program at Texas A&M University evaluated a wide range of peach cultivars and breeder selections from throughout the world during the mild winters of 1988-1989 and 1989-1990. Fruit shape response was highly variable among genotypes with similar chilling requirements. The implication of this is that the potential is high for eliminating fruit shape instability due to highly variable winter conditions in the Medium Chill Peach Production Region.

017 (PS VI)

BIENNIAL BEARING IN CRANBERRY. HOW EXTENSIVE IS IT?

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Biennial bearing has long been thought to occur in cranberry (*Vaccinium macrocarpon* Ait). Researchers have shown that percent return bloom on fruiting uprights can range from 12% to 65% depending on year, bed vigor and cultivar. Resource limitation and/or hormonal factors in a fruiting upright may be related to flower bud initiation and, thus, percent return bloom the following year. This research was undertaken to determine the extent of biennial bearing by cranberry cultivar and growing region. Seven cultivars were studied; three found in all states (MA, NJ, WI, OR), two common to MA and NJ, and two different cultivars in WI and OR representing cultivars commercially grown in these areas. In the fall or winter of 1989/1990 six 2-m transects were randomly selected within a cranberry bed for each cultivar. Along the transect, 60 uprights that fruited in 1989 were tagged. In the summer of 1990, fifty of the uprights will be sampled to determine percent return bloom and percent set.

018 (PS I)

**EFFECTS OF MUNICIPAL SOLID WASTE COMPOST AND FERTILIZER RATES ON BROCCOLI**

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Several companies and government agencies are now making municipal solid waste (MSW) composts. This study was undertaken to test effects of a MSW compost with different rates of fertilizer on broccoli. Treatments were compost at 0, 6.7, 13.5 and 26.9 MT/ha and fertilizer at 84 and 168 kg/ha N on a, fine sand soil. Treatments were applied, rototilled, and beds formed and covered with black plastic. Broccoli cv. 'Southern Comet' transplants were set on March 2 with 46cm between plants, 2 rows/bed, and beds centered at 1.8 m. Mature heads 15 cm and larger were harvested on April 25. Numbers of heads and total weight of heads were recorded and average head weights were calculated. Data analysis indicated main effect significance for fertilizer rate but not for compost rate with no interactions. The 168 kg/ha level of N resulted in a yield of 5795 kg/ha while the 84 kg/ha level produced 3849 kg/ha. Average head weights were 264, 262, 257, and 252 g; and marketable yield were 5.0, 4.8, 5.0, and 4.5 MT/ha; at 0, 6.7, 13.5, and 26.9 MT/ha, respectively.

019 (PS III)

**CRYOPRESERVATION OF PAPAYA SHOOT TIPS BY VITRIFICATION**

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Papaya shoot tips, obtained either from seedlings or from in vitro plants, survived liquid nitrogen (-196°C) exposure using a vitrification procedure. Vitrification is a technically simple method but requires large concentrations of cryoprotectants. These were added in two steps, first slow addition of dimethylsulfoxide (DMSO) and PEG-8000, and subsequent fast addition of ethylene glycol (EG). The final concentration before cooling was 40% EG, 7.8% DMSO, and 10% PEG-8000. Both rapid cooling and rapid warming rates were required. Differential scanning calorimetry (DSC) was used to determine that the external solution vitrified upon cooling. It could not be demonstrated by DSC that cells within the shoot-tip vitrified, but since both DMSO and EG rapidly permeate plant cells, vitrification within the cells seems a likely explanation for retention of viability.

020 (PS VI)

**THE RELATIONSHIP BETWEEN APPLE INTERSTEM STARCH CONCENTRATION AND DWARFING EFFECT**

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The dwarfing potential of apple interstems has long been recognized. This study was undertaken to examine the relationship between the dwarfing effect of apple interstems and interstem starch concentration. In 1981 apple trees with P2 or P22 interstems on clonal Antonovka rootstock using Jerseymac or Starkspurmac as scion were planted. In 1989 and 1990 core samples from the interstems and root samples were analyzed for starch concentration. Roots always had higher starch concentrations than interstems. In the spring, P22 interstems had higher starch levels than P2 interstems, but in the fall the reverse was found. No difference in starch concentration was found between the Antonovka rootstock under the same interstem. However, root starch concentration was more stable under P22 than P2. Further, roots under P22 were lower in starch in the fall than in the spring. This suggests that P22, the more dwarfing interstem, may interfere with the transport of carbohydrates through the trunk, which may be a factor in dwarfing.

021 (PS I)

**YIELDS AND PETIOLE SAP POTASSIUM CONCENTRATIONS OF TOMATOES GROWN WITH FIVE POTASSIUM FERTIGATION LEVELS**

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'Celebrity' tomatoes (*Lycopersicon esculentum* Mill.) were grown in peat-perlite under greenhouse conditions with five potassium (K)

fertilization concentrations of 25, 50, 100, 200 and 300 (mg/liter) K in irrigation waters. Petiole sap K concentrations were monitored on a weekly basis with calorimetric paper test strips. Petiole sap K concentrations (ug/ml) were stable throughout crop development at each feed concentration. Total and marketable fruit yields increased linearly with increasing petiole sap K concentrations. However, the relationship between petiole sap K concentrations and K levels in the irrigation waters was quadratic with a plateau occurring at about 200mg K/liter in the irrigation waters. Corresponding maximum sap K concentrations obtained were about 6200 ug K/ml. Yield responded quadratically to increasing K levels in the irrigation system, with maximum yields occurring at about 200mg K/liter. Fruit yields appeared to decline as feed concentrations were increased beyond 200 mg K/liter. At optimum feed concentrations, maximum marketable yield of about 2.6 kg/plant were obtained on plants grown 21 weeks from seed.

022 (PS III)

**APPARENT INFLUENCE OF PEDIGREE ON MICROPROPAGATION OF MUSCADINE GRAPE**

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Nineteen cultivars of muscadine grape (*Vitis rotundifolia* Michx.) were divided into three classes based on the mean number of shoots developed during micropropagation. The cultivars in each class were then compared for pedigree similarities and common ancestors were identified. It was determined that the difficult to propagate class always had close direct lineage to either 'White Male' or 'Scuppernong', both selections from the wild. The intermediate class tended to be composed of newer cultivars which were more distantly related to 'White Male' and 'Scuppernong'. The easy to propagate class had diverse family histories and none of them included either 'White Male' or 'Scuppernong' for three or more generations. It is hypothesized that some factor, yet undetermined, has an influence on the ability of muscadine grape to be micropropagated.

023 (PS VI)

**SEASONAL CHANGES IN NONSTRUCTURAL CARBOHYDRATES IN CRANBERRY**

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Carbohydrate concentration may be important for flower initiation and fruit set in cranberry (*Vaccinium macrocarpon* Ait.). Fruit set has been shown to be a major limiting factor in yield component analysis. The objective of this research was to identify carbohydrate concentrations in cranberry tissues at various stages of development under field conditions. Samples of two cranberry cultivars, 'Stevens' and 'Searles' were collected during the 1989 season using a 13 cm diameter probe. Samples were divided into fruit, uprights, woody stems and roots. Carbohydrates were quantified by HPLC. Nonstructural carbohydrates were primarily sucrose, glucose, fructose and starch. Soluble carbohydrate concentration was stable throughout the season in tissues analyzed, while starch content was high early in the season then decreased during blossom and fruit set. This work shows that starch reserves in leaves and stems apparently are remobilized to support fruit set in cranberry.

024 (PS I)

**CARROT RUST FLY CONTROL FOR ORGANIC FARMERS**

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The carrot rust fly (*Psila rosae*) lays eggs in the crowns of carrots, celery, and parsnips. Its larvae are dark brown maggots which burrow into the crown and roots of the plants making them unsalable. This is a pest of economic significance in coastal plantings. This project evaluated several non-chemical strategies available to organic farmers over three growing seasons. These included the use of traps to monitor populations and determine fields where infestations are likely to occur, parasitic nematodes, the use of trap crops, and row covers as an exclusion technique. Floating row covers were the only successful treatment in reducing maggot damage in these fresh market carrots.

025 (PS III)

**SWEET CORN INBREDS WITH PARTIAL RESISTANCE TO NORTHERN LEAF BLIGHT AND STEWART'S WILT**

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Approximately 200 sweet corn inbred lines were screened for two years for resistance to northern leaf blight, caused by *Exserohilum turcicum*, and Stewart's wilt, caused by *Erwinia stewartii*. Inbreds with the best levels of partial resistance to races 1 and 2 of *E. turcicum* included IL11d, IL676a, IL677a, IL685d, IL766a, IL767a and IL797a. Inbreds with the best partial resistance to *E. stewartii* included IL126b, IL676a, IL767a, IL772a, IL774g, IL797a, IL798a and M6011. Several of these resistant and moderately resistant inbreds had common ancestors; however, inspection of pedigrees suggested that resistance was derived from Puerto Rican, Bolivian, and other tropical sources and/or dent corn. Thus, many of the sweet corn inbreds may carry different genes for resistance and can be used for the development of populations with improved resistance.

026 (PS VI)

**GROWTH, WATER RELATIONS, AND CARBON TRANSFER BETWEEN *CASTILLEJA INDIVISA* AND ITS HOSTS**

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*Castilleja indivisa* (Indian Paintbrush) normally grows hemiparasitically in association with various hosts. Research at Texas A&M University has shown that depending on which host plant is selected, growth rates are increased two to five times over *Castilleja* grown without a host.

Haustorial connections form between the roots of *Castilleja* and the roots of its host plant. Published papers show that water and nutrients are transferred from the host to the hemiparasite, although this has not been characterized on a quantitative level.

Water relations of *Castilleja* and various hosts are being examined by psychrometry to determine the importance of water transfer in the relationship. Carbon transfer and partitioning is being examined using steady state  $^{14}\text{CO}_2$  labeling. Water relations, carbon transfer, and host specific growth enhancement will be discussed.

027 (PS I)

**PRODUCTION AND ECONOMIC FEASIBILITY OF TRELLISING CUCUMBERS**

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Trellising was investigated for intensive, small-scale, fresh market cucumber (*Cucumis sativus* L.) production. Economic feasibility of trellising was examined. The cultivars Dasher II, Marketmore 76, and PetoTripleMech were evaluated using trellising and ground culture at two locations in Oklahoma. The cultivar PetoTripleMech is normally grown as a processing cucumber. Here it was evaluated as a fresh market entry. Trellising significantly improved marketable yield of the three cultivars at both locations in comparison to ground culture. PetoTripleMech yields were equal to, or better than, the fresh market standards Dasher II and Marketmore 76. Average marketable fruit weight was not affected by trellising. Economic analysis indicated that trellising is a viable management system for small-scale cucumber production because the gross and net returns to the producer were increased by 20% and 10% respectively.

028 (PS III)

**VERIFICATION OF AN INTERGENERIC HYBRID BETWEEN DESERT WILLOW AND CATALPA**

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Desert willow (*Chilopsis linearis*) is native to the arid southwestern U.S. and is used as a landscape shrub. Catalpa (*Catalpa bignonioides*) is a small tree common in the southern U.S. that is used as a landscape plant. Both species have showy flowers and are members of the Bignoniaceae family. Controlled crosses were made using pollen from a single catalpa tree and desert willow stigmas

of the cv. 'Marfa Lace'. Fruit developed normally and seven seedlings were produced that had leaf morphology intermediate between the parents. From starch gel electrophoresis, putative hybrids had isozyme banding patterns consistent with hybridization between the parent species. A second biochemical verification is being conducted using probes for ribosomal RNA genes.

029 (PS VI)

**GROWTH AND NUTRIENT UPTAKE PATTERNS OF AN EPISODIC AND CONTINUOUS GROWING WOODY PLANT**

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Current recommendations for sufficiency of nutrients in soil-less media for container grown nursery crops have been based on weak acid extraction and pour through sampling of media. Since the concentration of nutrients found in pour through samples are similar to those available in the media solution, sufficiency levels as determined by hydroponics studies have also been considered to be applicable to plants grown in a solid medium such as pine bark. Many variables, however, may affect nutrient availability in a solid medium which are not the same as those in a well-stirred hydroponics system. Objectives of this experiment were to compare growth and nutrient uptake patterns of *Euonymus kiautschovica* 'Manhattan' and *Prunus persica* 'Jefferson' grown in a pine bark/sand medium or a hydroponics system. Quantitative growth characteristics, depletion rates of nutrients in solution, concentration of ions in pour through samples, and tissue levels of N, P, K, Ca, and Mg will be reported.

030 (PS I)

**INCREASE IN COWPEA REPRODUCTIVE DURATION AND PRODUCTIVITY INDUCED BY HARVESTING PODS AT COLOR-BREAK**

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Removal of pods from legume crops may extend reproductive duration by delaying leaf senescence. In two years of field experiments, cowpea (*Vigna unguiculata* [L.] Walp. cv. CB5) pods were continuously harvested as they reached color-break or southernpea stage. The largely monocarpic reproductive pattern of non-picked CB5 was altered to a bimodal distribution by picking. During the first podding period, removal did not appreciably change reproductive duration nor the number of pods produced. It reduced dry weight in seed 22-34% and significantly delayed leaf senescence relative to the non-picked control. This increase in source:sink ratio was accompanied by increasing starch concentrations in stems and was followed by generation of a second set of pods which doubled the reproductive duration of picked plants. By contrast, starch reserves declined during the first podset in senescent control plants, which produced few pods thereafter. Picked plants produced 41-60% more pods/m<sup>2</sup> over the entire season than non-picked CB5, but total dry weight in seed did not differ significantly since pod removal limited seed fill.

031 (PS III)

**GENETIC STUDIES OF *CUCUMIS MELO* L. RESISTANCE TO *MYROTHECIUM RORIDUM***

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Genetics of the host-pathogen interaction between *Cucumis melo* L. (muskmelon) and *Myrothecium roridum* were investigated by evaluating six populations: the parents, F<sub>1</sub>, F<sub>2</sub>, BCP, and BCP<sub>2</sub> of crosses between 'Hales Best' (tolerant), 'Perlita' (intermediate) and 'Iroquois' (susceptible). A spore inoculation bioassay with detached-leaves was used to determine levels of resistance. Resistance was determined by measuring necrotic lesion diameter, chlorotic plus necrotic lesion diameter, and a subjective rating score. Parents and F<sub>1</sub>s had consistent performance while the segregating generations were inconsistent. Factors contributing to the response will be discussed.

032 (PS VI)

CONTROL OF POINSETTIA GROWTH AND PIGMENTATION BY MANIPULATING LIGHT QUALITY  
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*Euphorbia pulcherrima* 'Glory' were grown under natural photoperiods from 5 Oct. to 20 Dec. in specially constructed growth chambers equipped with clear double-walled polycarbonate panels filled with liquids that served as spectral filters. The filters were a blue dye that increased far-red/red (FR/R) light, a  $\text{CuSO}_4$  solution that decreased FR/R, and  $\text{H}_2\text{O}$  (control) which did not alter FR/R from natural light. The FR/R values were 1.01, 0.86, and 0.34 for blue dye,  $\text{H}_2\text{O}$  (natural), and  $\text{CuSO}_4$ , respectively. FR and R were measured at 725-730 and 655-660nm, respectively.

Plants grown under the  $\text{CuSO}_4$  filter were 32% shorter, with shorter internodes (48%), greater leaf chlorophyll (25%), and more lateral branches (17%) than controls. Plants grown under blue dye filters did not differ from controls. All plants developed normal bracts and flowers.

033 (PS I)

MEDIA AND ENVIRONMENTAL INFLUENCES ON SOMATIC EMBRYOGENESIS IN COMMON BEAN (*PHASEOLUS VULGARIS* L.)  
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Opaque globules formed on bean callus induced on primary leaf explants cultured on induction media (IM) containing 10 to 30 mg/l 2,4-D. Calli with globules produce structures reminiscent of somatic embryos (embryoids) after subculture in a liquid challenge medium (LCM). Calli maintained on IM for 2, 3, 4, and 5 weeks produced significantly more (26 to 34/callus) embryoids in LCM than calli maintained on IM for one week (12/callus). Well developed embryoids only occurred after calli were subculture in liquid B5 with 0.1 to 1.0 mg/l IBA. Calli subculture in LCM with > 10 mg/l IBA turned necrotic and died. Embryoids produced in B5 with 2,4-D and NAA (0.1 to 1.0 mg/l) proliferated roots and formed "frosty" appearing structures, respectively. No differences were detected in number or quality of embryoids produced in LCM from callus maintained on IM in continuous light or darkness regardless of the induction time. Ethylene accumulation in IM cultures inhibited globule formation.

034 (PS III)

BLIND NODES IN PEACH: ENVIRONMENTAL AND GENETIC PARAMETERS

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Blind nodes in peach, the condition in which a node has no obvious vegetative or reproductive buds, is a problem in peach production in low and medium chill regions. Observations were made at 3 locations in Texas on peach cultivars which range in chilling requirement from 150 to 850 chill units. Four types of growing shoots (terminal or lateral shoot and east or west side) from peripheral canopy about 150-200 cm were sampled twice a month to determine the phenological development. Blind bud development was most frequent during the period of highest daily temperature and did not correspond with the position of the sample on a tree. High chilling cultivars showed greater susceptibility to the symptoms than low chilling cultivars. The anatomical differences between normal and blind nodes are described.

035 (PS VI)

ANALYSIS OF FRUIT BUD PROTEINS ASSOCIATED WITH PLANT DORMANCY

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Plant dormancy research has long been stifled by the lack of appropriate biochemical markers to characterize the changing physiological status of dormant vegetative or reproductive buds. Two sets of experiments were conducted in an attempt to identify changes in

soluble protein profiles during endodormancy of peach and blueberry reproductive apices. Bud samples from the peach cultivars 'La Festival' (low chilling requirement) and 'La White' (moderate chilling requirement) were taken every 15 days in the orchard during December and January, extracted for soluble proteins, and analyzed by one-dimensional sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE). Outshoots were forced at 25C in a growth chamber to determine the intensity of endodormancy. A further experiment utilized potted 'Bluechip' and 'Meader' (troth high chilling requirement) blueberry plants given varying periods of cold (4.5C) chamber treatment, followed by forcing at 25C in a growth chamber. Bud samples were taken following cold treatment for extraction and SDS-PAGE. The relationship of the resulting protein profiles to chilling unit accumulation and intensity of endodormancy will be discussed.

036 (PS I)

AN IRRIGATION SCHEDULING MODEL FOR TURNIP GREENS

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An irrigation scheduling model for turnip greens (*Brassica rapa* L.) was developed and validated. The irrigation scheduling model is represented by the equation:  $12.7(i-3) * 0.5 ASW = 0_{i-1} + E(0.365 + 0.00154i + 0.00011i^2) - R - I$  where crop age is  $i$ ; effective root depth is  $12.7 * (i-3)$  with a maximum of 300 mm; usable water (cm /cm of soil) is 0.5 ASW; deficit on the previous day is  $D_{i-1}$ ; evapotranspiration is pan evaporation (E) times  $0.365 + 0.00154i + 0.00011i^2$ ; rainfall (R) and irrigation (I) are in millimeters. Yield measured as leaf weight, and quality analyzed in terms of color (Gardner XL20 cronameter L, a, b), leaf blade and blade : stem weight ratio were determined. Leaf yield and quality responses were affected by both irrigation and fertilizer rates. Yield increased quadratically as irrigation rates increased from 0 to 190% of the model rate. Maximum leaf yields were produced by irrigations at 100% of the model rate. Leaf quality parameters also tended to change quadratically with irrigation rates. Leaf yield and quality changed quadratically as nitrogen fertilizer rates increased from 80 to 120% of the median recommended N rate for Georgia.

037 (PS III)

SOIL-BORNE FUNGAL RESISTANCE IN LYCOPERSICON PENNELLII ACCESSIONS.

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Forty-two *Lycopersicon pennellii* Corr. D'Arcy accessions, from the Tomato Genetics Stock Center, were inoculated for resistance to Fusarium wilt race 3 at the 3-leaf and cotyledon stage. All were over 90% healthy when inoculated at the 3-leaf stage but had greater disease incidence at the cotyledon stage. Crosses were made between healthy plants within each accession. Using this seed, 39 accessions were 100% healthy and 3 were over 96% healthy when inoculated at either stage. Seventeen  $F_1$ 's with susceptible parents were tested for race 3 and all had over 80% healthy plants. Twenty-two accessions were tested for Fusarium wilt race 1 and race 2. For race 1, 21 were 100% healthy and 1 was 91% healthy. For race 2, 20 were 100% healthy, 1 was 96% healthy, and 1 was 75% healthy. Forty accessions were screened for Fusarium crown rot and Verticillium wilt. For crown rot, LA 1277, LA 1367, and LA 1657 were over 95% healthy, 6 other accessions were over 68% healthy and several others had over 50% healthy plants. All 40 were susceptible to Verticillium wilt race 1. *L. pennellii* appears to be a good source of resistance to Fusarium sp. but not to Verticillium wilt.

038 (PS VI)

MAACKIA AMURENSIS NODULATES AND FIXES DINITROGEN

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*Maackia amurensis* Rupr. & Maxim. is a leguminous tree with potential for increased use in urban landscapes. Information on the nutrition of *M. amurensis* is limited. To our knowledge, modulation and  $\text{N}_2$  fixation have not been reported. Our objective was to examine *M. amurensis* for nodulation and  $\text{N}_2$  fixation. Soil samples

were collected near legume trees at arboreta throughout the United States, with additional samples from Canada and China. Seedlings were grown for six weeks in a low-N, sterile medium and inoculated with soil samples. Upon harvest, small white nodules were found on the lateral and upper portions of the root systems. Bacteria were isolated from the larger nodules, subculture, and used to inoculate seedlings. Inoculated plants nodulated and fixed N<sub>2</sub> as determined by the acetylene reduction assay. We conclude *M. amurensis* forms N<sub>2</sub>-fixing symbioses with *Rhizobium*.

#### 039 (PS I)

##### CABBAGE CULTIVAR EVALUATION IN WEST-CENTRAL FLORIDA

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Cabbage cultivars and advanced breeding lines were evaluated in a full-bed mulch system with a population of 43,200 plants/ha during the winter seasons of 1988-89 and 1989-90. Yield and adaptability were assessed for 31 entries in 1988-89 and 30 entries in 1989-90. Highest yields in 1988-89 were produced by 'Grand Slam' with 84.2 t/ha and an average head weight of 2.2 kg. Next highest yields were produced by 'Blue Boy' (74.1 t/ha), 'Rio Verde' (73.0), 'Bravo' (70.5), 'Ocala' (70.0), 'Showboat' (70.0), 'Olympic' (69.2), 'Sure Vantage' (66.6) and 'Grand Prize' (64.7). Heat tolerant cabbage entries 'Summer Autumn', 'Good Season', 'Tropical Delight', 'Spring Light', 'Summer Summit' and 'Summit' performed very poorly. Highest yields in 1989-90 were produced by XPH 5787 (77.1 t/ha), 'Showboat' (76.2), 57-340 (74.0), 'Blue Boy' (72.4), 'Bravo' (71.1), 'Tempo' (70.6), XPH 5788 (66.1) and 'Fortuna' (65.9). Highest yields among the fifteen cultivars tested both seasons were produced by 'Blue Boy' (73.3 t/ha), 'Showboat' (73.1) and 'Bravo' (70.7).

#### 040 (PS III)

##### EFFECTS OF GENOTYPE AND ENVIRONMENT ON FRUIT BUD DENSITY IN PEACH AND NECTARINE

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In the Southeast spring frosts often kill all or part of the flowers on peach trees. Increased flower bud density is one mechanism that increases the likelihood of enough flowers surviving to produce a crop. Mean buds per node in North Carolina varied in 1986 from 1.6 for 'Harko' to 0.4 for 'Topaz'. The effect of environment on bud density was unknown. Therefore, for 3 years we compared the bud density of 25 peach and nectarine cultivars grown in completely randomized designs (4 reps per location, 10 twigs per tree) in Georgia and North Carolina. Genotypic variability was greater than that due to location or year effects. Cultivars selected for high bud density in one location can be expected to have high densities at other locations.

#### 041 (PS VI)

##### ROOT CONDUCTANCE AND MORPHOLOGY OF SOLUTION- AND SAND-CULTURED HONEY LOCUST SEEDLINGS OF DIFFERENT AGES

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Root hydraulic conductance is often expressed on the basis of dry weight or surface area of leaves or roots of plants produced in solution or aggregate culture. In this study, biomass partitioning and its influence on the interpretation of root hydraulic conductance data were compared in 21- to 63-day-old *Gleditsia triacanthos inermis* Willd. (honey locust) seedlings grown in solution and sand cultures. The ratio of lamina to root dry weight decreased as seedlings aged but was always greater for solution-grown plants than for sand-grown plants. Expressed on the basis of root dry weight, steady-state water fluxes at applied pressures  $\geq 0.28$  MPa and hydraulic conductivity coefficients declined with root system age, with a sharp decrease among solution-grown plants between ages 21 and 35 days. Such a difference was not detected using data expressed on lamina surface area or dry weight, illustrating that caution must be exercised when reporting and comparing the conductance of roots cultured in different media.

#### 042 (PS I)

##### ORGANELLE SEGREGATION FOLLOWING CAULIFLOWER PROTOPLASM FUSION

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Cauliflower protoplasts with male fertile and *Ogura* male sterile cytoplasm were fused. Organelle reassortment and recombinant mitochondria were found in calli and plants regenerated from the fused protoplasts. Pretreatment (gamma-irradiation or iodoacetate) and protoplasm source (leaf or hypocotyl tissue) were manipulated in a series of fusions to determine their effects on organelle segregation. Some regenerated plants appear to combine *Ogura* male sterile mitochondria with normal *Brassica* chloroplasts. Plants with this organelle combination should be free of the cold temperature chlorosis due to incompatibility between the *Brassica* nucleus and the radish chloroplasts of the *Ogura* cytoplasm. These plants may have potential for improved cauliflower hybrid production.

#### 043 (PS III)

##### USE OF PROGENY TESTING TO ASSESS FAMILY POTENTIAL IN THE UNIVERSITY OF FLORIDA STRAWBERRY BREEDING PROGRAM

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Progeny testing, both formal and informal, has been a component of the University of Florida strawberry breeding program. Informally, the potential of numerous parental combinations has been assessed by growing small populations of each combination, and then ranking these populations according to visual impression. Formal progeny testing, where variables are measured on seedlings in a replicated measurement block, was used during the 1987-88 season. Several families were identified as promising, based on an analysis of yield, fruit size, firmness, and appearance data.

#### 044 (PS VI)

##### IS PECAN PRODUCTION BEING LIMITED BY INSUFFICIENT SUNLIGHT?

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Observations of net assimilation rates ('A') by pecan sun and shade leaves in relation to various levels of solar irradiation, the light adaptation characteristics of these leaf types, the role of clouds in suppressing the penetration of solar irradiation, and the abundance of cloud cover in the southeastern U.S. during the growing season, suggest that nut production throughout the U.S. pecan belt is being limited by insufficient sunlight with the southeastern U.S. (comprising about 2/3 of the commercial U.S. pecan production) being especially impacted. In support of this hypothesis, regression analysis showed cultivar-type nut production for Georgia from 1977-1989 to be significantly ( $P < .0001$ ,  $R^2 = 0.79$ ) associated with sunlight levels  $\geq 3000$  Wh m<sup>-2</sup> d<sup>-1</sup> from mid August to early October for the same year. This is taken as evidence that the amount of sunlight reaching the canopy seems to be a major factor that should be considered in relation to orchard site selection and canopy management techniques.

#### 045 (PS I)

##### TEMPERATURE EFFECTS ON SHORT SEASON PIGEONPEAS.

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Five early maturing pigeonpea (*Cajanus cajan*) genotypes; ICPL 146 1985HK, ICPL 87 Isolation (85K), ICPL 85010, ICPL 85024 and ICPL 8304 were evaluated in a growth chamber study and in a greenhouse/outdoor study. Genotypes grown in growth chamber at 25/15°C, day/night with 14 hour photoperiod and light intensity of 480  $\mu\text{Em}^{-2}\text{sec}^{-1}$ , produced 5-7 main stem branches within the first 7 weeks and flowered within 54-65 days. Those grown at the same conditions but with 10°C night temperature produced only 1-4 branches in the same period and flowered between 65 and 79 days. Plants grown in the greenhouse in the fall when photoperiod was 13½ hours, and temperature ranged from 31-42°C during day and 9-18°C during night flowered in 55 to 65 days. These plants grew faster than those started outdoors, where average weekly temperature was below 10°C for 4 of the 5 weeks before their transfer to the greenhouse and eventual flowering between 75 and 94 days. Some outdoor seedlings experienced epicotyl damage by a -1°C cold and these initiated shoots from axillary buds on underground nodes and flowered within 98-101 days.



## 046 (PS III)

PATHWAYS OF BACKCROSSING *ZINNIA ANGUSTIFOLIA* × *Z. ELEGANS* INTERSPECIFIC HYBRIDS TO THE PARENTAL SPECIES

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Allotetraploid *Z. angustifolia* × *Z. elegans* hybrids (2n=46) were reciprocally backcrossed to *Z. angustifolia* (2n=22 or 44) and *Z. elegans* (2n=24 or 48). Pollen germination and pollen tube penetration of the stigmatic surface were observed for all 8 cross combinations. At 14 days after pollination, the percentage of florets with embryos ranged from 0 to 69%, and some hybrid embryos exhibited developmental abnormalities. Seed-propagated backcross (BC<sub>1</sub>) populations were generated with *Z. angustifolia* (2n=44) as ♀ or ♂, and *Z. elegans* (2n=48) as ♀. BC<sub>1</sub> progeny from these 3 crosses demonstrated low to high levels of resistance to bacterial leaf and flower spot (incited by *Xanthomonas campestris* pv. *zinniae*) and high levels of resistance to powdery mildew (incited by *Erysiphe cichoracearum*). BC<sub>1</sub> hybrids derived from crossing allotetraploid hybrids as ♀ and *Z. elegans* (2n=48) lines have commercial potential as disease-resistant, flowering annuals.

## 047 (PS VI)

## CULTIVAR VARIATION IN APPLE FRUIT GROWTH RATES, SORBITOL ACCUMULATION, AND TISSUE OSMOTIC POTENTIAL

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Absolute and relative fruit growth rates (AGR and RGR) of 5 cultivars were calculated from the oven-dry weights of fruits harvested periodically throughout the growing season. Both AGR and RGR were higher for larger fruit of different cultivars with similar days to maturity, and for summer- versus fall-ripening cultivars. Seasonal variability in AGR and RGR was observed. Apple fruit cortex disks were incubated in <sup>14</sup>C-sorbitol solutions *in vitro* to determine if uptake rates at the cellular level varied between cultivars. Rates of sorbitol accumulation, expressed as µg sorbitol per mg dry weight cortex tissue, declined as the season progressed. Within a cultivar, uptake rates were not related to fruit size, nor were differences found between cortex tissue samples from competing fruit on a spur. Sorbitol uptake rates were significantly lower for the more slowly-growing cultivar. The osmotic potential of the expressed cortex sap, sampled on several dates, was consistently lower for the more rapidly-growing cultivar. Thus, inherent differences in fruit growth rates among cultivars may be due to variation in regulation of osmotic potential.

## 048 (PS I)

## PLANT REGENERATION IN VITRO FROM THE EMBRYONIC AXIS OF COMMON AND TEPARY BEANS

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Regeneration *in vitro* from the embryonic axis in *Phaseolus* sp. has not been reported. Two embryo sizes, 0.3-0.4 mm and 0.6-0.7 mm long at 10-12 and 21 days after pollination, respectively, were excised from 4 *P. vulgaris* (P.v.) and 2 *P. acutifolius* (P.a.) genotypes. The embryonic leaves and radicle were removed, and 0.1-0.2 mm of the embryonic axis was cultured on Gamborg's B<sub>5</sub> medium with 0, 5, 10 and 20 µM BA. The cultures were incubated in the dark at 25°C for 2 weeks followed by 1 week in continuous cool white light (25 µM MS<sup>-</sup>m<sup>-2</sup>) before transferring to the second medium (0, 2 µM BA and 2 µM BA + 4 µM GA<sub>3</sub>). The tissues from the larger embryos initiated a single shoot without PGR in 30% of 1 P.v. explants and 30-60% in 2 P.a. The other 3 P.v. formed roots only. Multiple shoots were initiated in all P.v. (15-60%) and in 2 P.a. (60 and 70%) with 5 or 10 µM BA. The tissues from the smaller embryos had single shoots for all genotypes (30-60%) without PGR. Multiple shoots were initiated in 50-80% and 75-90% of the explants from P.v. and P.a., respectively, with 5 or 10 µM BA. Excess callus formed with 20 µM BA and regeneration decreased. After 3 weeks on the second medium, 6-8 shoot s/P.v. and up to 15-20 shoots/P.a. explants were observed.

## 049 (PS III)

## ABOVE-GROUND SCREENING FOR GENETIC VARIATION IN CUCUMBER ROOT GROWTH

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An above ground screening method to study cucumber root growth was developed using the herbicide banding technique of Robertson et al. (Crop Sci 25:1084, 1985). Those roots that grow deeper or faster, sooner reach the herbicide, and sooner exhibit herbicide damage symptoms. Greenhouse pot trials showed that 1/4 - 1/2 lb/A atrazine could be used to produce

distinctive symptoms, differentiate between depths of banding, and among different genotypes. Based on root washing experiments of a few cultivars, root length and/or mass correlated with herbicide symptom expression. One hundred diverse cucumber genotypes were tested in the greenhouse. Time to symptom expression was normally distributed among the genotypes; analysis of variance indicated significant genotypic differences. The herbicide banding technique was also useful for monitoring cucumber root growth in the field. Response time and severity varied with herbicide concentration, depth, and distance from the seed row. The diverse cucumber genotypes are now being tested in the field to further determine if there are significant genotypic differences and to compare greenhouse and field behavior.

## 050 (PS VI)

## TARGET CELLS FOR PATTERN FORMATION DURING ADVENTITIOUS ROOTING IN ENGLISH IVY. Robert L. Geneve, Department of Horticulture, University of Kentucky, Lexington, KY 40546

Adventitious root formation in debarked petiole cuttings of English ivy proceeds via a direct rooting pattern for the easy-to-root juvenile phase, while the difficult-to-root mature phase roots through the indirect pattern. Juvenile petiole cuttings treated with NAA (100 µM) plus the polyamine biosynthesis inhibitor, DFMA (1 mM), formed an increased number of roots per cutting initiated through the indirect rooting pattern. The increased formation and the change in rooting pattern were reversed by the addition of putrescine (1 mM). Delaying auxin application to petiole cuttings for 15 days, also induced juvenile petioles to root by the indirect pattern. This could be reversed by rebounding the base of the cutting prior to auxin application at day 15. The data support the use of the terms "pre-competent root forming cells" (PCRFC) and "induced competent root forming cells" (ICRFC) to describe the target cells for the initial events of root formation for the direct and indirect patterns, respectively.

## 051 (PS I)

EFFECTS OF NaHSO<sub>3</sub> ON GROWTH AND YIELD OF BELL PEPPER

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Sodium hydrogen sulfate (NaHSO<sub>3</sub>) in aqueous solution was sprayed on bell pepper (*Capsicum annuum*) plants beginning at first anthesis to test its effects as a photorespiration repressor and resulting effects on yield. NaHSO<sub>3</sub> sprays promoted plant height, stem diameter, fruit number and plant weight and increased the net assimilation rate, thus increasing yield. Concentrations of 60, 100, 120, 130, 200, 240 and 300 ppm were all effective, with 200 ppm optimum. Sprays repeated for three times at 7 day intervals were more effective in increasing growth and yield of bell pepper than spraying once or twice. This technique has gained acceptance as a practical method for improving production of bell pepper in Northeast China. Additional research is underway to further refine this practice.

## 052 (PS III)

REGENERATION AND AGROBACTERIUM TUMEFACIENS - MEDIATED TRANSFORMATION OF CUCUMBER (*CUCUMIS SATIVUS* L.)

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We sought to develop efficient regeneration and transformation procedures for cucumber. Factors tested for regeneration included: hormone types and levels, genotype, explant source, and environmental conditions. Optimum regeneration was obtained using cotyledon pieces from 4 day old GY14A seedlings and culturing for 3 weeks under cool white lights (30-40 µE s<sup>-1</sup>) on MS medium supplemented with 1.0 mg/l 2,4-D, 0.5 mg/l BA, 0.3 mg/l ABA, 30 g/l sucrose, 1 g/l MES, and 3.07 g/l Scott gelrite. Shoots developed via somatic embryogenesis ca. 2 wk after explants were transferred to MS supplemented with 20 g/l sucrose, 1 g/l MES, and 4.37 g/l gelrite. Ca. 80% of the explants produce shoots, 1/3 - 1/2 of which produce rooted plantlets; total time from explant to rooted plantlet is ca. 8 wks. Transformation experiments utilized *Agrobacterium tumefaciens* strain LBA4404 bearing the CIBA-GEIGY pCIB10 vector with a selectable marker gene for kanamycin resistance. Optimal conditions include 45 mg/l kan, 10 min inoculation and 3 day co-cultivation. Preliminary evidence suggests that tobacco nurse cultures increase transformation efficiency. Transgenic plants were confirmed by Southern or dot blot analysis.



053 (PS VI)

#### EFFECT OF PHOTOPERIOD ON FLOWER INITIATION OF COFFEE

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Floral initiation in coffee has been shown to be stimulated by short days in young plants, but the inductive stimulus for mature plants is still not clear. Experiments were conducted to determine whether floral initiation in immature and mature plants is promoted by short photoperiods, and delayed by long photoperiods. In a growth chamber study, 18-month-old coffee (*Coffea arabica* L. cv. Guatemalan) plants exposed to 8 hr photoperiods developed flower buds after 4 weeks, whereas no floral initiation was observed on the plants exposed to 16 hr photoperiods for ten weeks. Trees growing in the field were illuminated with incandescent light from midnight to 3:00 a.m. from July to December 1989. The control plants received no artificial light during the same time period. Night light interruption delayed flower initiation until the end of December on branches that were fully exposed to the light. On control trees, flower buds started to emerge at the beginning of November. These results indicate that in immature and mature coffee plants floral initiation is stimulated by short days, and delayed by long days.

054 (PS I)

#### SEASONAL CHANGES IN ASPARAGUS ROOT GROWTH IN CONVENTIONAL AND NOTILL SYSTEMS

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Published data on the spatial patterns and periodicity of root growth in asparagus are limited. During the 1989 growing season growth and distribution of both fleshy and fibrous roots were monitored in a 7 year old asparagus planting. Soil cores were removed at 15 cm intervals to a depth of 90 cm at 40 and 80 cm from the plants in asparagus beds which had been maintained under conventional (CT) and no-till (NT) production systems. Fleshy and fine roots were separated from the soil and root length densities calculated. Harvests began in late March and continued at three week intervals until early November. Fine root growth was greater in the NT than CT in all depths and at both locations in March. Greatest lengths of fine roots were at the 15-60 cm depths for both CT and NT. This pattern was consistent throughout the season. Fine root lengths decreased by one half by the middle of the year (July) and remained at those levels until the last harvest (Nov). Fleshy root lengths were more variable, however NT generally had greater lengths than CT. Greatest length of fleshy roots were located in the 15-60 cm depths for both CT and NT treatments. Few fleshy roots were found below the 60 cm depth.

055 (PS III)

#### CHARACTERIZATION OF SOMACLONAL VARIATION IN TISSUE CULTURE-DERIVED TANGERINE-VIRESCENT LINES OF TOMATO

Dae-Geun Oh\* and Edward C. Tigchelaar, Department of Horticulture, Purdue University, West Lafayette, IN 47907

The tangerine-virescent (*tv*) mutation was reported as a single gene somaclonal variant from tissue culture (Evans and Sharp 1963). A replicated field trial was conducted to characterize variation and stability in the phenotype of this *tv* somaclone and to compare it with the inbred parent from which it was reportedly derived.

Heritability and stability of the *tv* somaclonal variant was measured by comparing R<sub>1</sub> and R<sub>2</sub> lines of sexual progenies of the original *tv* variant and with its sexually derived inbred parent UC82B. Several additional variants were observed in these *tv* lines, including fruit shape, days to first flower, fruit weight, yield, plant type, and fertility. Eight sterile or semi-sterile plants were discovered in 6 of 39 R<sub>1</sub> lines. Our results suggest that multiple genetic changes have occurred in the *tv* somaclonal variant and while the original *tv* mutant is stably inherited, additional genetic abnormalities occur following sexual reproduction.

#### Reference:

Evans, D.A. and W. R. Sharp. 1983. Single gene mutations in tomato plants regenerated from tissue culture. *Science* 221:949-951.

056 (PS VI)

#### CELLULAR LOCALIZATION OF SUCROSE SYNTHASE IN CALAMONDIN FRUIT BY IMMUNOHISTOCHEMICAL MICROSCOPY

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Localization of sucrose synthase (SS), an enzyme previously shown to be highly active in transport tissues of citrus fruit, was

further defined via immunohistochemical analysis of stage II calamondin fruit. Using the indirect immunogold technique, 8  $\mu$ m sections were first reacted with rabbit anti-SS polyclonal serum followed by incubation with 5 nm gold conjugated goat-anti-rabbit IgG. Little immunolabel was observed in the majority of peel tissues, however an abundant immunoreaction was evident in parenchyma cells directly adjacent to the segment epidermis surrounding juice sacs. Antibody was not associated with this epidermal layer. Similarly, in juice vesicle stalks (JVS) the internal parenchyma cells showed significant SS localization compared to minimal immunoreaction in the epidermal layers of the JVS. Although the antigen did not appear to be specifically localized within the vascular bundles, an extensive distribution of the enzyme was associated with the parenchymatous cells immediately adjacent to vascular strands.

057 (PS I)

#### VERIFYING STINK BUG AND COREID BUG INJURY TO PECAN KERNELS BY EXAMINING PECAN SHELLS

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Severe economic losses in pecan crop productivity result from phytophagous stink bugs and coreid bugs (Hemiptera) feeding on the kernel. Discriminating hemipteran damage from other late seasonal kernel disorders is often inconclusive. Two additional markers of hemipteran damage have been distinguished and can be used as unequivocal evidence of the feeding activity of these insects regardless of the source of the nuts. Staining pecan nuts with red fluorescent dye differentiates the microscopic hemipteran punctures from the natural markings on the shell. Additional confirmatory evidence can be obtained by recognition of the stylet sheaths connecting the packing material on the shell interior to the seed coat of the kernel. These anatomical evidences of hemipteran feeding should facilitate research studies to evaluate the role of hemipteran attack with late seasonal pecan kernel disorders.

058 (PS III)

#### GENOTYPE EFFECT ON THE SHOOT-FORMING CAPACITY OF TOMATO AND INCIDENCE OF SOMACLONAL VARIANTS IN HETEROZYGOUS REGENERANTS

Francisco A. Ferreira\*, Dae-Geun Oh, and Edward C. Tigchelaar, Department of Horticulture, Purdue University, West Lafayette, IN 47907

Six F<sub>1</sub>'s involving 6 multiple genetic marker stocks and a common inbred parent (PU812) were cultured to study the genotypic effect on regeneration ability and frequency of somaclonal variation in R<sub>1</sub> for the known heterozygous marker genes. Leaf discs 7 mm in diameter were excised from young fully expanded leaves of 6-7 week old plants, and cultured on MS medium supplemented with cytokinins (Kinetin, Benzyladenine) and IAA. With few exceptions, the parents and F<sub>1</sub>'s responded similarly to different hormone combinations. The best hormone combinations for shoot formation were 4 mg/l Kinetin + 0.5 mg/l IAA and 2.3 mg/l BA + 0.018 mg/l IAA.

Only 2 of the 6 multiple marker stocks and the common inbred parent (PU812) were successfully regenerated. Four of the six hybrids between PU812 and the multiple markers were readily regenerated, whereas 2 hybrids failed to regenerate with several different hormonal combinations. No mutations have been observed for the known heterozygous markers in 76 R<sub>1</sub> tissue culture regenerants.

059 (PS VI)

#### POINSETTIA DEVELOPMENTAL AND POST-PRODUCTION RESPONSES TO GROWTH RETARDANTS AND IRRADIANCE

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Plants of *Euphorbia pulcherrima* Wind. 'Glory' were grown under 13.4, 8.5, or 4.0 mol·m<sup>-2</sup>·day<sup>-1</sup> and sprayed with water (control); 2500 mg·liter<sup>-1</sup> daminozide + 1500 mg·liter<sup>-1</sup> chlormequat chloride (D+C); 62.5 mg·liter<sup>-1</sup> paclobutrazol; or 4, 8, 12 or 16 mg·liter<sup>-1</sup> uniconazole to ascertain plant developmental and post-production responses to the treatment combinations. Days to anthesis increased as irradiance was decreased. Anthesis was delayed by the D+C treatment, while other growth retardant (GR) treatments had no effect on anthesis. Irradiance did not affect plant height at anthesis, but all GR treatments decreased height over control plants. Bract display and bract canopy display diameters declined as irradiance was decreased. Growth retardants did not affect individual bract display diameters, but all GR treatments except paclobutrazol reduced bract canopy display diameter. Plants grown under lower irradiance had fewer axillary buds develop, fewer bract displays per plant, and fewer cyathia per bract display. Cyathia abscission during a 30 day post-anthesis evaluation was not affected by treatment; however, plant leaf drop was linearly proportional to irradiance. All GR treatments increased leaf drop over controls, and the D+C treated plants had the highest leaf loss. Results indicate the irradiance and GR treatments during production can affect poinsettia crop timing, plant quality at maturity, and subsequent post-production performance.

SEASONAL PATTERN OF VEGETATIVE GROWTH IN OKRA  
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Little is known about the morphology of okra (*Abelmoschus esculentus* Moench) plant. This information is critical to understanding of plant growth and possible factors limiting yield. Therefore, a field study was conducted during 1989 to determine the changes in leaf number, leaf dry weight and stem dry weight in okra during the fruiting period. Four okra genotypes, PI-178818, PI-211573, Lee and Clemson spineless, were planted in randomized complete block design with four replications. All four genotypes had similar stem dry weight, but differed significantly in leaf number and leaf dry weight. During the reproductive period, 42% of new leaves, 61% of leaf dry weight and 82% of stem dry weight were formed. PI-178818 had highest leaf number and maximum leaf dry weight, but produced lowest fruit yield. The results suggested that since vegetative growth and fruiting proceeds simultaneously in okra, partitioning of dry weight to pod maybe critical for high okra yields.

## 061 (PS III)

EVALUATION OF MENTOR POLLINATION FOR BLUEBERRY BREEDING  
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University of Florida, Gainesville, FL 32611

Two clones of anthocyanin-deficient (AD) *Vaccinium elliotii* (2x, homozygous recessive, yy) were used as seed parents in experiments combining normal and AD pollen. AD gives a seedling marker to distinguish the pollen parent. In the first experiment, flowers were pollinated daily for one, two, three or four days. AD and normal *V. elliotii* pollen were applied on separate days. The last day of each treatment received the opposite genotype from the previous day(s). The first pollination gave as many, or more, seedlings as later applications but the number of seeds per fruit was higher with multiple pollen applications. The second experiment used pollen from normal *V. corymbosum* (4x) alone or mixed with AD pollen from the 2x clones. Results depended on the seed-parent genotype. There was no difference between treatments in the number of hybrids produced by W81-1, which tends to set fruit even with only one seed per berry. Only mixed pollen yielded hybrids from clone FL83-139, which was never observed to produce berries with only one seed; apparently the mentor AD pollen helps to set the fruit, thereby allowing the rare hybrid seeds to develop.

## 062 (PS VI)

THE EFFECTS OF MICROGRAVITY ON THE CONCENTRATION AND DISTRIBUTION OF INDOLE-3-ACETIC ACID IN CORN SEEDLINGS  
Debra Reiss-Bubenheim\*1, Dr. Charles Winget 2, and Dr. Robert S. Bandurski 3  
1 Lockheed Engineering & Sciences Co., 2 NASA-Ames Research Center (ARC),  
Moffett Field, GA 94035, 3 Depart. of Botany, Michigan State University, East Lansing, MI 48824-1312

The gravity-sensing mechanism in plants and transduction of the gravity stimulus to re-orientating plant growth has not been ascertained. By removing the ever-present influence of the 1 g terrestrial environment on plant growth and development, information may be obtained about the gravity detection mechanism in plants. The Space Life Sciences Payloads Office at NASA-ARC processed the secondary Payloads flight experiment "Growth Hormone Concentration and Distribution in Plants" (GHCD). The experiment occupied two middeck lockers in the crew compartment onboard the space shuttle Atlantis (STS-34) in October 1989. The payload's Principal Investigator was Dr. S. Bandurski, Professor of Botany at Michigan State University. Dr. Bandurski's experiment was designed to investigate concentration, distribution, and turnover rates of indole-3 acetic acid (IAA) in dark-grown corn seedlings exposed to the microgravity environment. The flight data may provide valuable information for long-term crop production in space as well as terrestrial agriculture. This poster will present the flight payload processing procedures necessary to successfully conduct a space shuttle flight experiment.

## 063 (PS I)

IRRIGATION. SCHEDULING PROGRAM FOR ZUCCHINI SQUASH  
James E. Ellis\*, E. Gordon Kruse, and Ann E. McSay,  
Colorado State University, Fort Collins, CO 80523.

An irrigation scheduling program has been developed for zucchini squash that produced high yields and high water use efficiency with a minimum number of irrigations. The irrigation program is based upon a soil water balance model developed by the USDA. This irrigation program is available in diskette form and may be used with any IBM compatible personal computer provided wind run, temperature, solar radiation, humidity and precipitation data are available.

## 064 (PS III)

GROWTH HABIT TRAIT NOMENCLATURE IN ALMOND AND PEACH PHENOTYPES.

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Davis, Davis, CA 95616.

Almond (*Prunus dulcis* Mill) and peach (*Prunus persica* L.) are closely related species with many genetic traits in common. Variation in growth habit shows a consistent pattern among populations of peach, almond and their hybrid offspring. From this material a system of growth habit traits has been identified based upon genetically controlled processes of vegetative shoot elongation and flower bud initiation. All flowers are produced from lateral buds. The classification proposed for their characterization includes:

Class I. Growth from terminal buds on one year old shoots (six morphological groups).

Class II. Growth produced from lateral buds on 1-year old shoots (three morphological groups).

Class III. Combinations of Class I and II

These classes cover the entire range of peach and almond phenotypes and probably all *Prunus*. Class I is precocious and produces flowers by the second year from growth initiation. Class II plants do not produce flowers until the third year. Expression is enhanced by increase in vigor.

## 065 (PS VI)

USE OF SUPPLEMENTAL LIGHT TO ENHANCE GROWTH AND DECREASE NITRATE LEVELS IN GREENHOUSE GROWN SPINACH

Seenithamby Lgogendra, Harry W. Janes\*, Harry Motto and Gene Giacomelli, Department of Horticulture, Rutgers University,  
New Brunswick, NJ 08903

With the increasing establishment of greenhouses in conjunction with resource recovery projects (i.e., producing electricity by burning a low cost fuel), greenhouse facilities have access to low cost heat and in many cases electricity as well. In this regard we have been studying the production of spinach with the use of supplemental light.

The goal of the research was to establish the relationship between light and productivity and to also investigate the effects of light on tissue nitrate levels. The data indicate that an average daily PPF of 13-14 moles will provide enough energy to maximize the plant's relative growth rate. It was also found that supplemental HPS light with a PPF of 90  $\mu\text{moles/m}^2/\text{sec}$  given over a 12h period will increase the total light received by a plant in mid-winter by about 50% and lead to a 10% decrease in leaf nitrate level.

## 066 (PS I)

GROWTH AND YIELD OF EARLY, MID AND LATE SEASON CULTIVARS OF BROCCOLI AND CAULIFLOWER

Nanik Setyowati\* and Dean E. Knavel, Horticulture Department, University of Kentucky, KY. 40546, USA.

Plant growth and yield of broccoli ('Green Comet'), and cauliflower ('Majestic', 'Snow Crown') cultivars were evaluated by no-tillage (NT) and conventional tillage (CT) in the fall 1987 with  $\text{NH}_4\text{NO}_3$  applied dry or through the trickle line. Total plant dry weight, plant stand, average head weight, and number of heads harvested were not affected by tillage system. 'Snow Crown' plants had less of the following leaf area, dry weight, plant stand, number of heads harvested, and total head weight, than 'Majestic', especially in NT where  $\text{NH}_4\text{NO}_3$  applied dry. In the greenhouse, cauliflower cultivars had similar leaf area, leaf dry weight, and root dry weight at 30, 45, and 60 days after growing in sand culture while broccoli cultivars had similar leaf area, leaf dry weight, and root dry weight after 35, 50, and 65 days. Generally, nutrient uptake was similar at each sampling date for cultivars within crops. Cultivars had similar leaf water and osmotic potentials when grown for 2 weeks in modified growth chambers at either 23.9 or 29.4 C day, and 18.3 C night. These plants were then root-pruned and grown in sand culture for 3 weeks. Leaf area, root dry weight, and plant dry weight was greater for 'Majestic' than for 'Snow Crown' and 'Olympus'.

## 067 (PS III)

MODIFICATION OF THE BEAN BETA-PHASEOLIN GENE AND RELATED IMPACT ON EXPRESSION IN TRANSGENIC TOBACCO.

Nancy A. Reichert\* and John D. Kemp, Dept. of Horticulture, Miss. State, MS 39762 and Plant Genetic Engineering Lab, New Mexico State University, Las Cruces, NM 88003.

Beta-phaseolin, the seed storage protein gene isolated from French bean (*Phaseolus vulgaris* L.) displays the same developmental pattern of protein accumulation when transferred into tobacco (*Nicotiana tabacum* L.) The phaseolin gene was modified and then introduced into tobacco via *Agrobacterium tumefaciens* transformation to look for changes in phaseolin gene expression. Modifications included substitution of the

promoter region with that of CaMV 35S, the removal of 3, 4, or all 5 introns, substitution of the 3' untranslated region with that of nopaline synthase, and reversal of internal DNA sequences. All gene constructions (with the exception of those containing reversed sequences) displayed overall correct developmental regulation - phaseolin protein preferentially accumulated to comparable levels at the correct stage of seed maturation.

#### 068 (PS VI)

##### TRANSPIRATION OF A POTTED ROSE PLANT USING A HEAT BALANCE STEM FLOW GAUGE

Mark A. Rose\* and John W. White, Department of Horticulture, and Joel L. Cuello, Department of Agricultural Engineering, Pennsylvania State University, University Park, PA 16802.

Recently developed stem flow gauges that allow for direct, accurate, non-invasive, and continuous measurement of plant sap flow rates have not been used to monitor transpiration of floricultural plants grown in greenhouses.

A Dynamax SGA10 heat-balance sap-flow sensor was mounted on a potted rose plant's main stem containing a total leaf area of 0.52 m<sup>2</sup> in order to monitor transpiration. The sensor was connected to a CR21X Micrologger for data calculation and temporary storage. The results showed average midday sap-flow rates range from 20-30 g·hr<sup>-1</sup> to 50-70 g·hr<sup>-1</sup> at low and high levels of PPF, respectively. Nighttime levels of 4-7 g·hr<sup>-1</sup> persisted throughout early winter trials. Monitoring transpiration of the same rose stem using a lysimeter revealed a significant linear correlation ( $r^2 = 0.999$ ) between the lysimeter and the stem flow gauge values.

In the future, research will be conducted with the gauge to investigate relationships between microclimatic variables, photosynthesis, and transpiration.

#### 069 (PS I)

##### EVALUATION OF RAPID CYCLING BRASSICA AS A CANDIDATE OILSEED CROP FOR CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS

Jay Frick<sup>1</sup>, Manette A. Schonfeld<sup>1</sup>, Paul H. Williams<sup>2</sup>, and Cary A. Mitchell<sup>1</sup>, Dept. of Horticulture, Purdue Univ., W. Lafayette, IN 47907 and <sup>2</sup>Dept. of Plant Pathology, Univ. of Wisconsin, Madison, WI 53706.

The short time to flower and rapid production cycle of dwarf Brassica lines make it a promising candidate as an oilseed crop for NASA's Controlled Ecological Life Support Systems (CELSS) program. Breeding lines provided by Paul H. Williams are being screened at Purdue University for productivity and yield rate using soilless culture techniques under controlled-environment conditions. The small, irregularly-shaped Brassica seeds did not respond well to conventional methods of germination above the batch hydroponic systems, even when a variety of capillary ticking materials were used. At best, attaining uniformity of seedling stands required transplants, which compromised potential yield rates in terms of mechanical damage and inhibited seedling establishment. Present emphasis is on solid substrate soilless mixtures using passive ticking hydroponics systems. Crop growth rate, harvest index, and overall yield are being compared as a function of planting densities ranging from 117 to 1423 plants/m<sup>2</sup> of growing area. Yield parameters are also being evaluated as a function of growth medium and level of ambient CO<sub>2</sub> in the growth chamber atmosphere. Research sponsored by NASA Cooperative agreement NCC 2-100.

#### 070 (PS III)

##### GENERATING TETRAPLOID MELONS FROM TISSUE CULTURE

Jeffrey Adelberg\*, B.B. Rhodes and Halina Skorupska, Clemson University, Department of Horticulture and Department of Agronomy and Biological Sciences, Clemson, SC 29634

Watermelon (*Citrullus Lanatus* (Thunb.) Matsum and Nakai) and muskmelon (*Cucumis melo*) were regenerated from immature cotyledons cultured on MS medium containing 10 μM BA. Small population of watermelon and muskmelon regenerants contained tetraploids as variants. The tetraploid individuals were recognized by morphological features including enlarged leaves, tendrils, male flowers, and variable pollen grains. After self-pollination, seed lots reflected differences in size expected from tetraploid parents. Cytological data from root tips of R<sub>1</sub> populations will be presented.

#### 071 (PS VI)

Modification of Petunia seedling Carbohydrate Partitioning by Irradiance David F. Grarper\* and Will Healy, University of Maryland, College Park MD 20742.

Petunia × hybrida Villm. 'Red Flash' plants were irradiated for either 10 or 20 mol day<sup>-1</sup> photosynthetic photon flux (PPF) in growth chambers using one of the following treatments: 175 μmol m<sup>-2</sup> s<sup>-1</sup> for 16 h, 350 μmol m<sup>-2</sup> s<sup>-1</sup> for 8 or 16 h or 350 μmol m<sup>-2</sup> s<sup>-1</sup> for 8 h plus 8 h incandescent day extension (5 μmol m<sup>-2</sup> s<sup>-1</sup> PPF). These

four treatments were designed to examine the effects of increased peak and total daily integrated PPF as well as increased photosynthetic (Pn) period and photoperiod resulting from supplemental irradiance treatment of seedlings. Previous seedling petunia research indicated a greater response to supplemental lighting during expansion of the second true leaf. Therefore, seedlings were sampled for analysis at the two leaf stage and also later at the four leaf stage to examine effects at a later stage of growth.

Increasing total integrated PPF increased total carbohydrate production, seedling dry weight, rate of seedling growth, and acid invertase activity once the seedlings reached the two leaf stage. Increasing total PPF resulted in greater partitioning into ethanol soluble sugars rather than starch at the two leaf stage. Increasing the photoperiod only, with an incandescent day extension treatment, reduced total carbohydrate production at the two leaf stage.

Maximal oxygen evolution was observed when seedlings received 350 μmol m<sup>-2</sup> s<sup>-1</sup> for 8 h when expressed on a leaf area or dry weight basis. The use of an 8 h day extension treatment to extend the photoperiod from 8 to 16 h resulted in the lowest rates of oxygen evolution on a leaf area basis.

#### 072 (PS I)

##### DIURNAL VARIATIONS IN PHYSICAL AND CHEMICAL PLANT FACTORS AFFECTING FEEDING OF HOMALODISCA COAGULATA, A VECTOR OF DISEASES INDUCED BY XYLELLA FASTIDIOSA. Peter C. Andersen, Brent V. Brodbeck and R. F. Mizell, III., University of Florida Agricultural Research and Education Center, Route 4, Box 4092, Monticello, FL 32344.

*Homalodisca coagulata* (Say), a xylem-fluid feeding leafhopper, vectors diseases induced by the bacterium *Xylella fastidiosa* such as phony peach disease and Pierce's disease. The purpose of this study was to investigate plant factors that influence feeding. *H. coagulata* were confined to stems of peach [*Prunus persica* (L.) Batsch] and crape myrtle (*Lagerstroemia indica* L.). Osmolarity, amino acid and organic acid concentrations of xylem fluid were maximum during the morning for peach and declined thereafter; xylem fluid chemistry of crape myrtle followed a less distinct trend. Irrigated plants had higher concentrations of organic constituents and feeding rates were higher on these plants. Feeding rates and xylem fluid tensions, were maximum during midday; feeding did not occur at night. In separate experiments feeding rates were greatly reduced at xylem tensions >1.5 MPa.

#### 073 (PS III)

##### CRYOPRESERVATION OF DORMANT APPLE (*Malus sp.*) BUDS. Cecil Stushnoff\*, Philip L. Forsline, Leigh Towill and John Waddell. Dept. of Biochemistry, Colorado State Univ., Fort Collins, CO 80523, USDA-ARS-NAA, NYS Agric. Expt. Sta, Geneva, NY 14456 and USDA-NSSL, Fort Collins, CO 80523.

Cryopreservation of dormant buds has potential to provide back-up conservation of vegetatively propagated genetic resources for fruit crop species. This system may be useful where clonal integrity must be maintained and where it is desirable to rapidly recover plants with flowers for crossing purposes. In 1988, a pilot project involving the National Clonal Apple Repository at Geneva, NY and the National Seed Storage Laboratory, Fort Collins, CO, was initiated to test handling protocols as a prelude to establishing a cryopreservation back-up system for apple genetic resources. Sufficient buds have been cryopreserved to permit viability evaluation after 1 month, 1, 2, 3, 4, 5, 10, 15, 20, and 25 years storage in liquid nitrogen vapor phase storage (-150 °C). Recovery of dormant buds collected 12/12/88 and 02/06/89 after one month in LN<sub>2</sub> was 36% and 35%, respectively, for eight different taxa. After one year in LN<sub>2</sub>, recovery was 50% and 48% for the same taxa. The difference was attributed to improved handling during dehydration prior to patch budding for viability estimation. In 1990, recovery after 1 month in LN<sub>2</sub> was 38% for six different cultivars. The response to controlled acclimation and desiccation for 15 taxa will be presented.

#### 074 (PS VI)

##### POLYGALACTURONASE IN POLLENS

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Polygalacturonase (PG) in higher plants has been considered to be associated with ripening fruits although it is now known to be present in foliage and storage organs. We recently found very high levels of PG in some grass pollens (Plant Science 59, 57-62, 1989). This prompted an examination of other pollens for PG activity. All of the pollens analyzed contained PG but the range of activities was great. Eastern cottonwood pollen contained the most PG, with a level about 12 times higher than that usually found in ripe tomato fruit. Pollens from the other members of *Populus* were generally high in PG. Pollens from the oak family also

contained very high PG, with the highest amount in white oak pollen. Pollens from pecan, English walnut, willows, birch and hickories contained moderate levels of PG. The lowest amounts of PG were found in pollens from beech, sycamore and conifers. The PG's from the two richest sources (eastern cottonwood and white oak pollens) were partially purified and characterized. Both enzymes were found to be exopolysaccharidases that require  $\text{Ca}^{2+}$  for activity. PG may be involved in some function related to pollination but an explanation for the wide range of activities indifferent pollen is not obvious.

#### 075 (PS I)

##### PLANT REGENERATION FROM LEAF PROTOPLASTS OF LYCOPERSICON HIRSUTUM AND ITS INTERSPECIFIC HYBRIDS WITH L. ESCULENTUM.

T.J. Montagno\*, S.Z. Berry, and P.S. Jourdan, The Ohio State University, Dept. of Horticulture, Columbus, OH 43210-1096

*L. hirsutum* has been previously reported as recalcitrant to culture and plant regeneration. We have modified tomato protoplast culture protocols and obtained high frequencies of plant regeneration from leaf protoplasts of *L. hirsutum* PI 126445, LA 94, and LA 1393, as well as from 8 interspecific hybrids of PI 126445 (male parent) with *L. esculentum* 'Floradade', 'Marglobe', 'Tropic', 'OH7870', 'OH7983', 'OH832', 'OH8243', and 'OH8245'. Protoplasts were isolated from 3-week old low light pretreated seedlings and cultured in modified LCM containing 1 mg/L NAA 0.5 mg/L BA, and 0.5 mg/L 2,4-D. Cultures were kept in the dark at 30 C, diluted every 3 days with LCM containing only 0.75 mg/L BA and gradually moved to the light. After 2-3 weeks, colonies of 1-2 mm were transferred to solid MS medium containing 0.5 mg/L BA and 0.05 mg/L NAA. Calli containing dark green bud primordia were then placed on MS with 2% sucrose and 2 mg/L zeatin riboside for shoot production.

#### 076 (PS III)

##### RESPONSE OF IN VITRO PROPAGATED PEACHES IN VITRO AND IN MICROPLOTS TO MELOIDOGYNE INCOGNITA F.A. Hammerschlag\* and R.N. Huettel, USDA/ARS, Beltsville, MD 20705

Five in vitro propagated peach scion cultivars (Suncrest, Rio Oso Gem, Compact Redhaven, Redhaven, Jerseyqueen) and two rootstock (Nemaguard and Lovell) were screened in vitro and in microplots for their susceptibility to the root-knot nematode, *Meloidogyne incognita*. Evaluations in tissue culture for galling were conducted at 5 wk. Trees in microplots were evaluated for 3 years for nematode populations, trunk diameter, and yield. Comparative results indicated that the number and size of galls observed at 5 wk in vitro is indicative of the response of peaches to nematodes under field conditions after three years. Cultivar Compact Redhaven was significantly more tolerant to root-knot than 'Lovell' the most widely used peach rootstock. These results suggest that Compact Redhaven might be potentially useful as a rootstock in the Southeast where Nemaguard is used sparingly because of its lack of cold tolerance. In addition, these results indicate that in vitro screening holds promise as a rapid technique for evaluating root-knot nematode resistance.

#### 077 (PS VI)

##### POINSETTIA GROWTH AND DEVELOPMENT IN RESPONSE TO DAY-NIGHT TEMPERATURE REGIME AND UNICONAZOLE.

Richard J. McAvoy, Plant Science Department, University of Connecticut, Storrs, CT 06269.

Poinsettias, *Euphorbia pulcherrima* Willd. cvs Lilo and Diva Starlight, were exposed to either warm day-cool night or cool day-warm night greenhouse temperature regimes. Day time temperatures were imposed between 900 to 1600 HR. Within each temperature regime, poinsettias were grown single stem or pinched and drenched with either 0.04 or 0.08 mg a.i. uniconazole per 1.6 l pot or grown as untreated controls. Light levels (PAR) and potting medium and plant canopy temperatures were continuously monitored.

Over the course of the study, the day-night temperature differential (DIF), in the plant canopy, averaged 4.2C in the warm day regime and -1.4C in the cool day regime. The average daily temperature was lower (16.9C) in the warm day regime than in the cool day regime (18.7C).

DIF treatment significantly affected final leaf area, leaf and total plant dry weight, leaf area ratio and specific leaf weight. The DIF treatment by cultivar interaction was significant for final poinsettia leaf area, stem, leaf and

total plant dry weight, break number and average break length. Uniconazole significantly affected final plant height, stem and total plant dry weight, break number, average break length and specific leaf weight. Uniconazole by DIF treatment effects were not significant.

#### 078 (PS I)

##### POTASSIUM NUTRITION OF CABBAGE SEEDLINGS IN PINE BARK SUBSTRATES.

Graham J. Wright\* and Irwin E. Smith., Dept of Environmental Hort., IFAS, University of Florida, Gainesville, 32611, and Dept of Hort. Science, University of Natal, Pietermaritzburg, 3200, South Africa.

Composted pine bark is one of the most important substrates used in the seedling industry today. Previous work suggested the availability of inherent Potassium (K) in the bark. This research confirmed the availability of K and indicated that little or no K is needed for seedling production when pine bark is used as a substrate. Pre-enrichment rates ranged from 0 to 460 g.K.m<sup>-3</sup>, with a supplemental solution application of 0 to 200 mg.K.l<sup>-1</sup>. No evidence of K deficiencies or toxicities were detected. Three K sources, KCl, KNO<sub>3</sub>, and K<sub>2</sub>SO<sub>4</sub> were used in the pre-enrichment of the bark. No differences were noted for top fresh mass, seedling height, root dry mass, root to shoot ratio and percentage moisture. Seedlings grown in treatments without and supplementary K showed tissue contents of 162.5 mg.K.kg<sup>-1</sup>. This research suggests the possibility of reducing the levels of K applied to seedlings grown in a composted pine bark substrate.

#### 079 (PS III)

##### CHARACTERIZATION OF TRICHOMES IN THE LYCOPERSICON SPECIES USING SCANNING ELECTRON MICROSCOPY. Jacqueline A. Ricotta and John B. Masiunas, Department of Horticulture, University of Illinois, Urbana, IL 61801

In the past few years, leaf trichomes of tomato (*Lycopersicon esculentum*) and related wild species have received considerable attention due to their potential role in insect resistance. However, the last complete characterization of all 7 trichome types was by Luckwill in 1943, before the advent of scanning electron microscopy (SEM). Since that time, the taxonomic designations of the genus have been modified, expanding from 6 species to 9. The purpose of this work was to use SEM to observe and record trichome types from the presently accepted *Lycopersicon* species, and determine their species specific distribution. Studies have shown variation within trichome type due to number of cells per trichome, and base and surface characteristics.

#### 080 (PS VI)

##### THE EFFECT OF MAGNETIC FIELD ON WATER IMBIBITION AND RADICLE GROWTH OF SEEDS

Benjamin Liang\* and John M. Brown, Department of Horticulture, University of Missouri, Columbia, MO 65211

Nuclear Magnetic Resonance Imaging is currently being investigated as a nondestructively and noninvasively observing plant-water relationships. Researchers have not considered the effects of magnetic fields on plant growth and development. This study was conducted to investigate the effects of magnetic fields on seed water imbibition and radicle growth. Corn (cv. pioneer 3379), pea (cv. little marvel), and soybean (cvs. forrest and D86-4669) seeds were embedded in petri dishes with water saturated Smither's oasis

porous foam, and were oriented for the East, South, West, and North. Seeds were exposed to either 1.5 Tesla or 1x10<sup>-10</sup> Tesla static magnetic field for 48 hours. Changes in seed weights and radicle lengths were measured. Results showed that the strong magnetic field and seed orientations had no effect on the water imbibition rate. However, growth of corn and pea radicles was affected by the magnetic field. The 1.5 Tesla magnetic field enhanced the growth of corn radicle length, whereas it retarded the growth of pea radicles.

081 (PS 1)

PHOTOCONTROL OF *DIOSCOREA ALATA* PLANTLET GROWTH IN VITRO

Joan John, William Courtney, and Dennis R. Decoteau\*, Department of Horticulture, Clemson University, Clemson, SC 29634-0375.

The effects of light spectral quality on *Dioscorea alata* cv, Oriental in vitro grown plantlets were investigated. Cultured nodes were treated with red (R) or far-red (FR) light at the end of a 14 hr photoperiod. End-of-day (EOD) light treatments did not affect organogenesis. EOD FR light increased average internode lengths as compared to plantlets treated with EOD R light. The EOD FR enhancement of internode elongation was reversed by following the FR with R suggesting the involvement of phytochrome. There were no residual light effects on subsequent plantlet development from subcultured nodes or potted plantlets after EOD light treatments were terminated.

(082 (PS III))

POWDERY MILDEW INOCULATION TECHNIQUES FOR A Cucurbita moschata BREEDING PROGRAM

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In order to effectively use recurrent selection for developing polygenic resistance to powdery mildew (*Erysiphe cichoracearum*), methods to quantify resistance need to be developed. Our objective was to compare several inoculation methods for their effectiveness in a half-sib selection breeding program. Seven inoculation methods and 3 controls were applied to each of two susceptible *C. moschata* varieties planted in pots and arranged in a randomized complete block design with five replications. The experiment was repeated two times. Single degree of freedom comparisons found no difference in number of lesions resulting from inoculation by rubbing host with infected tissue vs. attaching infected tissue. Using no adherent resulted in as many lesions as using triton. Egg white as an adherent resulted in fewer lesions than using triton or no adherent. Spraying with a triton spore suspension was not an effective method. While rubbing leaves is fast and easy, attaching pieces of infected tissue may afford more control of spore concentration.

083 (PS VI)

EFFECTS OF CHANGING DIURNAL LIGHT ON GROWTH AND FRUITING OF APPLE

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The relationship of variability in flowering and fruiting habit to canopy position and changing diurnal light and photosynthetic pattern was examined in 7 mature spur-type 'Red Delicious'/MM106 apple trees. A .5x.5m column was placed in the north, south, east and west sections of tree canopies. Columns were subdivided by height with 3 study areas located at .25-.5m, 1.0-1.25m and 1.75-2.0m from the top of the canopy. In each, section, flowering index, fruit set, individual fruit weight and size, skin coloration, fruit soluble solids content, spur leaf area and spur bud diameter were determined. Photosynthetically active radiation and photosynthesis were measured from bloom through harvest correlated with variability in flowering, fruiting, spur quality and distribution of growth.

084 (PS 1)

CALCIUM FERTILIZATION AND CULTIVAR AFFECT WATERMELON RIND THICKNESS AND RESILIENCY

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Three cultivars of watermelon (*Citrullus lanatus*), 'Crimson Sweet', 'Charleston Gray' and 'Tri-X Seedless' were grown in combination with 4 levels of soil applied calcium (0, 280, 560, 1120 kg Ca/ha). Gypsum was incorporated into 6 m plots on 5 m centers then covered with black plastic mulch. Irrigation requirements were provided through a M-wall drip system and soil water status monitored with tensiometers. Transplants were spaced 1.2 m apart in-row spacing allowing for 5 plants per plot and replicated times. Rind tissue from mature watermelon fruit was divided into 4 sections, blossom-end, middle top, ground spot and stem end. Each section was measured for resistance to shear and puncture by a Model T-1200-G texture

and tenderometer system. Thickness was also measured. Lab determinations for total and extractable calcium on the sections was done to determine if there is a relationship between rind resiliency and calcium concentration. Data will be presented at the meeting.

085 (PS III)

HERITABILITY OF MANGANESE TOLERANCE IN RABBITEYE BLUEBERRY

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To determine whether manganese tolerance in rabbiteye blueberry (*Vaccinium ashei* Reade) is heritable, a 10-parent diallel cross was produced. A 250 ppm Mn solution (200 ml/plant) was applied to a sand culture, of the progeny daily. Visual ratings (1 - dead plant - 13 - no Mn toxicity symptom) were made after 6 weeks. Shoot weight and Mn content of leaves were determined. Narrow-sense heritability estimates ( $h^2$ ) were  $0.45 \pm 0.28$  for Mn content,  $0.49 \pm 0.27$  for visual ratings, and  $0.37 \pm 0.21$  for shoot weight. The genetic correlation between neither shoot weight nor visual rating and Mn content (0.11 and -0.15, respectively) was very high; however, the correlation between shoot weight and visual ratings (1.00) was extremely high. This suggests that visual ratings provide an estimate of Mn effects on plant  $h^2$  equal to objective measurements of shoot weight. Though  $h^2$  estimates for Mn content and visual ratings were similar, the lack of genetic correlation between the traits indicates that tolerance to Mn toxicity is independent of Mn content. The high  $h^2$  for visual ratings suggests mass selection as the method of choice for improving Mn tolerance in a rabbiteye blueberry population.

086 (PS VI)

WATER AND CARBON USE BY DEVELOPING FRUIT OF GRAPEFRUIT

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Transpiration, respiration, dry weight gain, and water accumulation were measured to quantify the total carbon balance, total water utilization, carbohydrate cost for fruit growth, and water use efficiency in developing fruit of grapefruit (*Citrus paradisi* Macf). Rate of net carbon loss and net water loss ( $\text{mg g}^{-1} \text{FW hr}^{-1}$ ) both decreased during fruit development. On a whole fruit basis, total carbon demand was reduced during the period of peak expansion, then increased rapidly during fruit maturation. In contrast, whole fruit rates of water loss and water utilization (loss plus accumulation) peaked at about 100 days after anthesis, then decreased toward fruit maturation. Carbohydrate cost for fruit growth was greatest ( $3.49 \text{ g sucrose g}^{-1} \text{DW}$ ) at the early stage of fruit development (immediately following anthesis), whereas water use efficiency peaked ( $193 \text{ mg DM g}^{-1} \text{H}_2\text{O}$ ) at the final stage of fruit development. The thickness of albedo and pectin content in fruit may contribute to the observed water conservation. Total estimated carbon cost of grapefruit development indicates approximately 120 g of sucrose would be necessary for production of a 450 g fruit (77 g DW) at 22 C.

087 (PS I)

INFLUENCE OF SPACING AND PRUNING ON ECONOMIC RETURNS OF STAKED TOMATOES

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Stable prices and increased competitive market pressures have caused many staked tomato producers to examine the costs and benefits of adopting intensive production practices such as drip irrigation and plastic mulch. Inclusion of these practices with traditional growing practices often results in a total production cost in excess of \$10,000 per acre. In 1988 and 1989, field studies were conducted in western North Carolina to determine if changes in plant spacing and pruning could reduce production costs, increase yields of large fruit and improve grower net returns from staked tomatoes (c. Mountain Pride). Combined data indicated that the greatest early season yields were obtained using early pruning (when suckers were 2-4 inches long) and in-row spacings of 18 inches or less. Net returns per acre were greatest when: 1) plants were pruned early and spaced closely in-row, which increased high priced early season yields and 2) plants were spaced 30 inches apart and either pruned early or not pruned, which increased total season yields. Non-pruned plants had lower yields of Jumbo and Extra Large size fruit, but higher total yields than pruned plants.

# CHROMOSOMAL LOCATION OF BIOTIN- AND FLUORESCIN-LABELED DNA BY *IN SITU* HYBRIDIZATION IN *ALLIUM*.

Agnes RICOCH, Robert J. BAKER and Ellen B. PEFFLEY\* Texas Tech University, Department of Agronomy, Horticulture and Entomology, Lubbock, Texas 79409-2134. USA,

Biotin- and fluorescein-labeled probe has been used to map specific sunflower rDNA sequences by *in situ* hybridization on mitotic chromosomes of *Allium cepa*, *Allium fistulosum* and interspecific hybrid derivatives. There are three hybridization sites in *A. cepa* and more than six in an interspecific triploid. This *in situ* hybridization technique offers new cytogenetic markers useful in the construction of a physical genomic map of *Allium* and offer a means to document introgression of these genomes.

# CAFFEINE AND THEOBROMINE ARE SYNTHESIZED BY TWO DIFFERENT PATHWAYS IN LEAVES OF *COFFEA ARABICA*

Gladys M. Nazario\* and Carol Lovatt, Dept. of Botany & Plant Sciences, University of California, Riverside, CA 92521

A study was undertaken to identify the pathway(s) leading to the synthesis of caffeine and theobromine in leaves of *Coffea arabica*. The relative contribution of purine nucleosides and bases to the biosynthesis of these alkaloids was assessed by measuring the incorporation of radiolabeled inosine, adenosine, adenine, hypoxanthine, and xanthine into caffeine and theobromine.

The results of this investigation suggest that caffeine and theobromine are end products of two distinctively different pathways. The incorporation of radiolabeled formate, adenosine, and xanthine was significantly greater into caffeine than into theobromine. Furthermore, exogenously supplied theobromine did not dilute the incorporation of [<sup>14</sup>C]formate, [<sup>14</sup>C]inosine, or [<sup>14</sup>C]xanthine into caffeine. In contrast, radiolabeled adenine was incorporated into theobromine but not into caffeine, and exogenously supplied adenine diluted the incorporation of [<sup>14</sup>C]adenosine into theobromine, but not into caffeine.

Taken together, these results provide strong evidence that theobromine is not a precursor of caffeine biosynthesis in leaves of *C. arabica*.

Supported by the Citrus Research Center and Agricultural Experimental Station of the University of California, Riverside,

# TALSTAR INSECTICIDE/MITICIDE FORMULATIONS: A REVIEW OF EFFICACY AND PHYTOTOXICITY IN ORNAMENTAL USE

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Talstar 10WP insecticide/Miticide (bifenthrin) is used for the control of a broad spectrum of economic pests on ornamentals. Over 100 species of greenhouse and field-grown plants, trees and shrubs have been shown to exhibit no phytotoxic response to the wettable powder formulation. Research efforts with alternative bifenthrin formulations, which exhibit equivalent pest efficacy and lack of phytotoxicity, may also provide unique application opportunities.

# SCREENING OPUNTIA ACCESSIONS FOR RESISTANCE TO COTTONY COCHINEAL INSECTS (*DACTYLOPIUS* SPECIES)

Joseph O. Kuti, Hort. Research Lab., College of Agriculture, Texas A&I University, Kingsville, Texas 78363.

Prickly pear (*Opuntia* spp.) fruits (tunas) and leaves (nopalitos) are consumed in Mexico and in the United States especially among groups of Hispanic origin. The plant is a natural host for cochineal insects which cause extreme damage to the stems of prickly pears. Fifteen accession of prickly pears belonging to *O. ficus-indica*, *O. fuscicaulis*, *O. inermis*, and *O. megacantha* were screened for genetic resistance to cochineal insects infestation under greenhouse conditions. Plants were infested with newly hatched crawlers (25 crawlers/plant) and production of white waxy filaments was evaluated eight weeks after infestation. No accession exhibited complete immunity but 5 accessions had significant ( $P < 0.05$ ) levels of genetic resistance when compared to other accessions. Accessions 'belonging to *O. ficus-indica* and *O. inermis* had the lowest filament production and the highest percentage of resistant plants.

# INVERTASES OF LILIUM LONGIFLORUM FLOWER BUDS

William B. Miller and Shi Niu\*, Department of Plant Sciences, University of Arizona, Tucson, AZ 85721

Sucrose is the major form of translocated carbohydrate in most plants. While enzymes of sucrose degradation have been well studied in many agronomic crop sinks, little is known about the physiology of sucrose breakdown in most floral tissues. Invertase and sucrose synthase are accepted as the key enzymes responsible for sucrose breakdown. As the first step in studying sucrose breakdown in *Lilium longiflorum*, we characterized floral bud invertase enzymes. Three soluble invertases were present in developing buds, and were resolved by DEAE-Sephacel chromatography (Invertases I, II, and III, in order of elution). After further purification, each enzyme was characterized. Each was an acid invertase (pH optima of 4.0 to 5.0), each had  $K_m$  values for sucrose of 5.0 to 7.0 mM. To determine if the enzymes had tissue-specific localization, anthers were dissected from tepal, pistil, and filament tissues. Invertase I was localized primarily in anthers, with invertases II and III being present in much smaller amounts. Invertases II and III were the major forms in the other floral tissues with essentially no invertase I detectable.

# PLANT ESTABLISHMENT OF BROCCOLI AS INFLUENCED BY PLANTING METHOD AND PLANT TYPE

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Studies were conducted in 1988 and 1989 to evaluate the influence of planting time and method on plant establishment and yield of fall broccoli. In 1988, plant establishment of direct-seeded broccoli was not improved with application of vermiculite (63 kg/ha), a cross-linked polyacrylamide polymer (17 kg/ha), or both as anti-crustants over the untreated check (37.6%, 32.2%, 24.6%, and 31% of target population, respectively). In 1989, transplants were compared with double-seeding (planting two seeds 25 mm apart). With seed germination of 55% in the early planting (8 Aug.), plant populations of double-seeding and transplants were similar, but 42% germination of double-seeding in the late planting (28 Aug.) resulted in lower plant populations than from transplants. While yield reflected differences in plant populations, the percentage of marketable heads from transplants was significantly greater (90.6%) than from seedlings (78.9%). These data suggest that broccoli transplants are a viable option when high soil temperatures may be detrimental to seed germination.

# TITER OF TOMATO SPOTTED WILT VIRUS IN THREE TOMATO SPECIES VARIES WITH THE LEAVES INOCULATED BUT NOT LIGHT INTENSITY

S.J. Scott\*, M. Stevens and R.C. Gergerich, Departments of Horticulture and Forestry, and Plant Pathology, University of Arkansas, Fayetteville, AR 72701

Three methods to inoculate *Lycopersicon esculentum* 'VF Pink' seedlings with tomato spotted wilt virus (TSWV) were compared. Treatments were 1) two inoculations by hand (rubbing leaves with a sterile cotton swab), 2) a single inoculation using a paint sprayer at  $3.56 \times 10^5 \text{ N} \cdot \text{m}^{-2}$ , and 3) two spray inoculations. All three methods were effective (>95% infection) under moderate temperatures in the spring, but hand inoculation was not effective under hot conditions in the summer. In another experiment, spray inoculation was used to compare effects of light intensity and the leaf inoculated on susceptibility of *L. hirsutum* PI 127826, *L. pimpinellifolium* LA 1580 and 'VF Pink' to TSWV isolate 85-9. All three genotypes were susceptible under full sun and 60% shade cloth in the greenhouse. Inoculation of youngest leaves produced the highest virus titer. Background optical density for noninoculated plants differed between lower and upper leaves in the ELISA assay.

# CHARACTERIZATION OF TRANSLOCATED CARBOHYDRATES AND DIURNAL CHANGES IN CHRYSANTHEMUM LEAVES

Susan E. Trusty and William B. Miller\*, Department of Plant Sciences, University of Arizona, Tucson, AZ 85721

Exudation of phloem sap into EDTA (ethylenediaminetetraacetic acid) solutions has been found to be a successful technique for qualitatively determining translocated



assimilates in many plants. Mature *Chrysanthemum* leaves were excised under a solution of 10 mM EDTA (pH 7.0). The petioles of these leaves were placed in EDTA, and leaf exudate was collected at intervals for 24 h. Soluble carbohydrates were determined with HPLC. While numerous sugars were present in the leaf, sucrose was the only sugar found in the EDTA solutions. The greatest rate of sucrose exudation occurred in the first two h after excision. Diurnal fluctuations of soluble sugars in *Chrysanthemum* leaves were also monitored in greenhouse-grown plants (late winter in Arizona). Sucrose exhibited a clear diurnal fluctuation, and nearly doubled in concentration (to appx. 25 mg/g DWT) in the afternoon relative to the low in the morning. Other leaf carbohydrates, including glucose, starch, and fructans showed diurnal variations as well.

#### 096 (PS I)

##### INFLUENCE OF NaCl ON APOPLASTIC ION ACCUMULATION AND WATER RELATIONS OF LEAFLET TISSUE OF PEA

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Pea (*Pisum sativum* cv. *Argenteum*) plants were exposed to nutrient culture solutions supplemented with 0, 50, 100, and 200 mM NaCl. Within 2 h after initial exposure, significant increases in Na concentration were observed within the apoplast of mesophyll tissue from fully expanded leaflets, as determined by elution analysis. Estimated apoplastic Na contents at 6 h ranged from 1.8 to 6.9  $\mu\text{mol Na/g fr wt}$  with the highest contents in leaflets from plants placed in 100 and 200 mM NaCl. Osmotic potentials of expressed sap from leaflets declined from -0.82 MPa at 0 time to -0.92 and -1.14 MPa by 3 h for the 50 and 100 mM NaCl treatments, respectively. K concentrations within the mesophyll apoplast were also found to increase within the short term in response to increasing nutrient solution NaCl concentrations. The potential short-term osmotic effects of apoplastic ion accumulation within leaf mesophyll tissue under saline conditions will be discussed.

#### 097 (PS III)

##### EVALUATION OF LYCOPERSICON GERMLASM COLLECTION FOR RESISTANCE TO TOMATO SPOTTED WILT VIRUS

S.J. Scott, M. Stevens\* and R.C. Gergerich, Departments of Horticulture and Forestry, and Plant Pathology, University of Arkansas, Fayetteville, AR 72701

Seedlings of eight accessions of *L. hirsutum* and susceptible *L. esculentum* 'VF Pink' controls were spray inoculated twice in the greenhouse with tomato spotted wilt virus (TSWV) Arkansas 85-9. Plants lacking symptoms were reinoculated, then evaluated for TSWV by enzyme-linked immunosorbent assay (ELISA). Controls were consistently infected; sixty noninfected *L. hirsutum* were propagated by cuttings and inoculated with TSWV isolates T2 (lettuce), G-87 (gloxinia), 87-34 (tomato) and a mixture of the four isolates. All selections became infected in at least one test, but systemic infection was often delayed. Additional wild *Lycopersicon* species and numbers of accessions evaluated for resistance to TSWV include *L. cheesmanii* (9), *L. chmielewskii* (17), *L. hirsutum* (24), *L. hirsutum* f. *glabratum* (17), *L. parviflorum* (4) and *L. pennellii* (44). No new sources of strong resistance have been identified yet. Evaluation of additional species and accessions is continuing.

#### 098 (PS VI)

##### FRUCTANS ISOLATED FROM FLOWERS AND STEMS OF CHRYSANTHEMUM MORIFOLIUM

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In order to more fully understand flower growth and development, we are interested in carbohydrate partitioning and metabolism in floricultural crops. In recent work with *Chrysanthemum*, we noted the occurrence of several early-eluting carbohydrate peaks (as detected by HPLC with a resin-based column in the calcium form). These peaks were present in flowers and stems, and in lesser amounts in leaves. Acid hydrolysis of the unknowns liberated large amounts of fructose and much smaller amounts of glucose, indicating that these peaks are fructans, or

medium chain-length fructose polymers. Fructans represented 10% and 25% of the carbohydrate in a 12:5:3 methanol:chloroform: water extract of leaves and stems, respectively. Flower petals were extracted with 95% ethanol, then with water. Fructans accounted for more than 40% of the water soluble carbohydrate in flower bud tissue. It is likely that fructans serve as a major reserve carbohydrate in *Chrysanthemum*. Additional studies are underway to better characterize flower petal fructans, and to understand their role in flower development.

#### 099 (PS I)

##### NUTRIENT UPTAKE OF SWEET POTATO CULTIVARS IN FRITTED CLAY MEDIA

Ndolo, P.J.\* and E.G. Rhoden, G. W. Carver Ag. Expt. Station, Tuskegee University, Tuskegee, AL 36088.

A greenhouse study was conducted to investigate the uptake, accumulation and percent recovery of N, P, K, Ca and Mg by sweet potato (*Ipomoea batatas*) cv 'TI-155', 'Centennial', 'Georgia Jet' and 'Rojo Blanco'. These cultivars were grown in a fritted clay medium and harvested after 42 and 82 days. There were no significant difference in total elements uptake among the cultivars at 42 days. However, Georgia Jet accumulated more P and K than TI-155 and had higher levels of K than Rojo Blanco at day 82. Total accumulation of elements increased significantly from 42 to 82 days. Leaves accounted for most of the plant N at both harvest periods. Storage roots contained significantly more K than leaves, vines or fibrous roots. Percent N, P and K uptake was significantly lower at 42 than at 82 days. Cultivars also had no significant difference in percent uptake at day 42. However, at day 82, Georgia Jet showed a significantly higher P and K percent recovery than Rojo Blanco.

#### 100 (PS III)

##### PLANT GROWTH REGULATOR EFFECTS ON SEED TRACE DEVELOPMENT AND GERMINATION OF FOUR STENO-SPERMIC GRAPE CULTIVARS

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Various plant growth regulators were used to stimulate endosperm and embryo development in four stenospemic grape cultivars. Five antigibberellins were applied to clusters at 1000 and 100 ppm two weeks prior to bloom. Two cytokinins were applied at 1000, 500, and 250 ppm 20 days after bloom. Combinations of the treatments were also made. Data collected included: 1) cluster weight, 2) berry weight, 3) number of 'sinker' and 'floater' seed traces, 4) 'sinker' weight and 5) percent germination. Significant differences were found among treatments for some of the variables. Differences also occurred among cultivars. Percent germination was greater for cultivars with large seed traces. The technique appears to have promise as an alternative to ovule culture/embryo rescue for intercrossing stenospemic grapes.

#### 101 (PS VI)

##### DOES CHRYSANTHEMUM DISPLAY AN ENDOGENOUS CIRCADIAN RHYTHM OF STEM ELONGATION?

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The rate of internodal extension of chrysanthemum (*Dendranthema grandiflora* Tzvelev. cv. *Envy*) under various temperature and photoperiod conditions was studied to determine whether reproducible diurnal patterns of growth existed and whether any such patterns conformed to an endogenous circadian rhythm. Stem growth was monitored continuously by means of linear displacement voltage transducers. At constant temperature and under 11 h light/13 h dark photoperiod, stem elongation followed a clearly defined pattern consisting of a peak in rate immediately after the dark to light transition and then a gradual decline until the start of the dark period. During darkness, elongation rate increased and reached a maximum approximately 8 hours after the light to dark transition. This pattern differed when light period temperature was either above or below dark period temperature, but these patterns were also highly reproducible. When plants were subjected to continuous light at constant temperature, the rhythm of stem elongation initially showed a periodicity of approximately 27 hours. After 2 or 3 diurnal cycles the rhythm was less distinct and the rate became essentially constant. Furthermore, the interruption of a long period of continuous light with a 13 h dark period did not restore the rhythm. These findings do not support the existence of an endogenous circadian rhythm of stem elongation. Diurnally-cued rhythms do, however, exist and can be modified by temperature.



102 (PS I)  
EFFECT OF GYPSUM ON EARLY GROWTH AND YIELD OF SWEET POTATO.

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A study was conducted to assess the effects of gypsum on the early growth and storage root yield of sweet potato (*Ipomoea batatas*) cvs 'Jewel', 'Georgia Jet' and 'TI-155'. Three rates of gypsum were applied (1.03, 2.06 and 3.09 tons/acre). These represented half, recommended and 1.5 recommended levels. The experiment was a randomized complete block design with a split plot arrangement of treatment. Leaf area, total dry matter, leaf dry matter and stat-age root weight were recorded at 30-day intervals. Plants receiving half the recommended levels of gypsum produced the highest total storage root dry matter (0.306 t/a) and the highest leaf dry matter (0.116 t/a). Although a positive relationship exists between leaf dry matter and storage root yield between 90 and 120 days, there was no such relationship between those parameters either at 30 and 60 days or 60 and 90 days after transplanting.

103 (PS III)

REGENERATION AND TRANSFORMATION OF VFNT CHERRY TOMATO

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Regeneration from VFNT Cherry tomato was optimized prior to transformation. Cotyledon and hypocotyl sections from 7-day-old in vitro grown VFNT Cherry tomato were cultured on medium containing MS salts, B5 vitamins and the following per liter: sucrose, 30g; zeatin, 1 mg; IAA, 0.1mg; agar, 8.0g or Gelrite\*, 2.2g. Culture conditions investigated included cotyledon and upper hypocotyl explant lengths, light vs. dark germination, and agar vs. Gelrite\*. The conditions which resulted in the highest average number of shoots per explant were cotyledon basal explants 2 mm in length, 3.95; cotyledons from dark germination, 6.2; and hypocotyls from light germination, 8.6. An equal number of shoots regenerated on medium containing agar or Gelrite\*, however, shoots regenerated on medium containing agar were more vigorous. Cotyledon and hypocotyl sections were cocultivated with the *Agrobacterium tumefaciens* binary vector pBI121 containing the neomycin phosphotransferase II (NPTII) and B-glucuronidase (GUS) genes. Transformants were selected by regeneration and rooting on medium containing kanamycin. Southern blot and PCR analysis indicated regenerants contain the NPTII and GUS genes. Mapping the chromosomal location of the NPTII gene is in progress.

104 (PS VI)

IMPROVED HPLC RESOLUTION AND QUANTIFICATION OF ELLAGIC ACID FROM STRAWBERRY, BLACKBERRY, AND CRANBERRY

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Ellagic acid (EA) a naturally occurring polyphenol in many fruit and nut crops, is a putative inhibitor of certain chemically-induced cancers. Improved methods of extraction, detection and quantification are essential for accurate determination of EA for plant physiological and genetic studies and animal nutrition and chemopreventative studies. Column (C18) preconditioning significantly reduced column retention of EA. An ammonium phosphate/methanol solvent system was used in preference to sodium phosphate/methanol. Fruit sample determinations were 10-100 times higher than previously reported, due to the improvements in efficiency of these methods. EA levels (mg/g dry wt) were: strawberry pulp (1.55), achene (8.46), root (1.55), crown (3.32) and leaf (14.27); blackberry pulp (2.43) and seed (3.37); and cranberry skin (1.06), pulp (0.31), seed (0.69), leaf (4.10).

105 (PS I)

CONTROL OF PERENNIAL GRASSES ON CULTIVATED AND UNCULTIVATED LAND

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This experiment was conducted to determine effects of herbicides on the control of noxious perennial grass weeds. The results indicate that the rate, timing, duration and number of applica-

tions employed were the major factors in the successful control of perennial grass weeds such as Cogon Grass (*Imperata cylindrica*), Johnson Grass (*Sorghum halepense*), Bermuda Grass (*Cynodon dactylon*), Nut Grass (*Cyperus rotundus*) and Common Red (*Phragmites* spp.), commonly found in Iraq growing both in cultivated fields and wild on uncultivated land.

106 (PS III)

THE NATURE AND MEANS TO OVERCOME HYBRID BREAKDOWN IN THE F<sub>2</sub> OF AN INTERSPECIFIC CROSS IN *LYCOPERSICON*

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The transfer of multigenic traits into tomato has been slow due to interspecific barriers (hybrid breakdown) found in the F<sub>2</sub> of the *Lycopersicon esculentum* × *L. pennellii* cross (esc × pen), including blocks in normal reproductive development and nonfecundity. In a typical (esc × pen) F<sub>2</sub> population, failure to flower and premeiotic blocks in pollen development occurred in 2% and 11% of the population, respectively. The remaining plants showed a mean of 37% stainable pollen. Twenty three percent of the F<sub>2</sub> plants set seed, with an average of 4.5 seeds/fruit. An average of 33% of the stainable pollen from the 7 F<sub>2</sub> plants with the highest stainable pollen measurements germinated in vitro, but only 4 of these 7 plants set seed. Thus, percent stainable pollen is not an adequate predictor of fecundity, and the non-fecundity in the F<sub>2</sub> Le plants must involve barriers occurring after pollen germination.

A method was developed which greatly reduces or eliminates each of the F<sub>2</sub> barriers. The method and its efficacy on each of the aspects of hybrid breakdown will be discussed.

107 (PS VI)

BLUE LIGHT AND ELEVATED CO<sub>2</sub> INDUCE LIGNIN SYNTHESIS IN WHEAT

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The role of spectral quality and CO<sub>2</sub> concentration in environmental control of lignin synthesis in spring wheat is being studied by the NASA Controlled Ecological Life Support System Program (CELSS). Wheat cultivars were exposed to four different spectral environments provided by 1) metal halide lamps (MH), 2) high pressure sodium lamps (HPS), 3) low pressure sodium lamps (LPS; almost monochromatic, 589 nm), or 4) LPS plus low irradiance blue light (5 μmol m<sup>-2</sup> s<sup>-1</sup>; LPS + Blue) at equal photosynthetic photon flux. Stem lignin content was suppressed 25% under the LPS compared with the MH and HPS; blue addition (LPS + Blue) resulted in 25% greater lignin content compared with the LPS alone and 8% suppression compared with MH and HPS. CO<sub>2</sub> studies compared lignin content of wheat grown in the field, greenhouse at 350 μmol mol<sup>-1</sup> CO<sub>2</sub>, and growth chambers at 350 and 700 μmol mol<sup>-1</sup> CO<sub>2</sub>. Lignin content was greatest and equal in the field and growth chamber at 700 μmol mol<sup>-1</sup> CO<sub>2</sub>. Lowest lignin content was measured in the growth chamber at 350 μmol mol<sup>-1</sup> CO<sub>2</sub>; lignin content in the greenhouse was intermediate between that measured in the field and growth chamber at 350 μmol mol<sup>-1</sup> CO<sub>2</sub>. Additional CO<sub>2</sub> studies in controlled environments will be discussed.

108 (PS I)

VEGETABLE AND GRAIN AMARANTH SEED YIELD AND QUALITY AFFECTED BY APPLIED NITROGEN

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Twenty-one day old seedlings of a vegetable amaranth (RCC 241, *Amaranthus tricolor*) and a grain amaranth (K343, *A. hybridus* × *A. hypochondriacus*) were transplanted on July 28, 1989. Equal applications of NH<sub>4</sub>NO<sub>3</sub> were made on July 28 and August 25 to give total N rates of 0, 60, 120 and 240 kg/ha. Accessions were harvested on Oct. 18 and 14, respectively. Increasing N, induced a quadratic response in plant dry wt, seed wt/plant and seed size fractions in both amaranth types. Seed size fractions as a percent of the total seed, plant height and seed to plant dry weight ratio were not affected by increased N. Seed protein increased linearly whereas seed nitrate increased quadratically with increasing N application. Higher N rates increased residual soil NO<sub>3</sub>, NR, and electrolytes and decreased pH. Decreasing soil pH appeared to reduce soil K and Cu but increase Fe and Mn availability. The effect of N rate on seed germination was inconclusive, but the larger seed size was higher in germination. There were differences among species in most responses tested. These data suggest that N applications be tailored to the season growing length required by the respective species/cultivar.

## THE UNILATERAL INTERSPECIFIC CROSSING BARRIER IN LYCOPERSICON IS NOT SELF INCOMPATIBILITY

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Little is known about the mechanisms controlling interspecific barriers, unlike the well studied intraspecific barrier, self incompatibility (SI). A unilateral crossing barrier (unilateral incongruity - UI) exists among the *Lycopersicon* species, in which crossing is impeded or prevented in one direction. Since both UI and SI can give unilateral differences in seed set, suggestions have been made that UI and SI are functionally related. *L. pennellii* LA716 is self-compatible, unlike the other accessions which are SI, but LA716 still exhibits UI with *L. esculentum* (*esc*). We observed the development of pollen tubes in self and cross pollinations of LA716, *esc* and SI accessions of *L. pennellii* (*pen*). Selfed pollen tubes in *esc* were at the ovary in 24 hours, while *pen* were 1/2 way down the style and in LA716 the pollen had not germinated. By 48 hours, the pollen tubes in LA716 were in the ovary and growth had halted in *pen* styles. Crosses with LA716 pollen on *esc* and *pen* resulted in pollen tube growth starting within 24 hours continuing to the ovary. Thus, UI is not a SI response and LA716 shows a delayed pollen germination and growth unlike the other *Lycopersicon* species examined.

## 110 (PS VI)

## THE EFFECT OF THE AGE OF THE OVARY ON GROWTH AND FINAL FRUIT SIZE OF TOMATO GROWN IN TISSUE CULTURE

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Growing tomato fruits in tissue culture, using ovaries, could be used as a model system to study fruit development and sink strength/activity. Producing a "normal and healthy" fruit is essential in developing this system. Many factors affect the growth and development of the fruit. The objective of this study was to investigate the effect of the age of the ovary (i.e., the number of days after pollination) on growth and final fruit size. The results indicate that the fruit size, root development, and uniformity in growth of the fruit were affected by the initial age of the ovary. The older the ovary, the greater was the final fruit size and uniformity. The development of root mass was not affected by the age of the ovary until 7 days of pollination. However, root development was suppressed in ovaries that were of 9 days after pollination. The fruits from younger ovaries were more irregular in shape. All the fruits from ovaries harvested at 9 days after pollination were more uniform and round as compared to other treatments.

## 111 (PS VI)

## TOMATO FRUIT SIZE AS AFFECTED BY ROOT MASS IN TISSUE CULTURE

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The effect of root mass on tomato fruit size in tissue culture was studied. The root mass of the ovaries was changed either by growing in culture media containing different concentrations of NAA ( $\alpha$ -naphthaleneacetic acid) or by culturing the ovaries with and without sepals. The root mass increased with a decrease in NAA concentration from 10.0 to 2.5  $\mu$ M and the ovaries with sepals developed more roots. The tomato fruit size was affected by the root mass. The greater the root mass, the larger was the fruit size. However, the larger fruit size from ovaries cultured with sepals could be attributed either to the presence of more roots (greater absorption of sucrose) or to the sepal (additional carbon fixation by photosynthesis), or to both the sepals and more roots. Moreover, it is possible that the presence of sepals induce root development. These results indicate that the presence of sepals and total root mass are two important factors that influence the fruit size *in vitro*.

## 112 (PS I)

## ORGANICALLY GROWN CARROTS HAVE DISTINCT TASTE AND STORABILITY

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Carrots cv. 'Nantes' were grown on a Rugbee soil type which was treated before planting with 1, 5, and 10 MT/ha of moose manure (MM). Each treatment was replicated five times and compared to the

standard practice (SP) of 500 kg/ha 10-10-10 fertilizer. No pesticides were used. Yields were difficult to obtain because of bear vandalism. At harvest 10 kg. samples of each were washed and blended in a food processor. A taste panel of 12 members evaluated a 10 ml. sample in a white paper cup. Each panelist was blindfolded because samples differed in color. 98% of the panel members found the MM carrots to have a distinct taste and preferred them over SP carrots. Two weeks after the test 76% of the panel had a craving for wild oats. Carrots from the treatments were held in underground storage for 5 months. To complete the biology cycle an attempt was made to feed the stored treatment carrots to the moose but they would eat only the SP carrots. For samples of the MM carrots contact Bill Miller, Program Co-Chairman, The first person to respond will receive a certificate for a free meal at the Sizzler on Congress Street.

## 113 (PS III)

## GREENHOUSE WHITEFLY RESISTANCE IN SELECTED INTERSPECIFIC HYBRIDS OF LYCOPERSICON

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Selected interspecific hybrids between *Lycopersicon esculentum* and 11 wild species accessions were evaluated for level and type of resistance to *Trialeurodes vaporariorum*. The interspecific hybrids were clonally propagated and evaluated for antibiosis to non-sexed adult whiteflies, larvae development to the 3rd or 4th instar and reproduction of a second generation of adults. The test unit was a fully mature and expanded leaf containing only 4 leaflets and an 11 cm stem section sitting in a bottle of weak nutrient solution. One detached leaf-stem section from each entry was randomly placed in one of 12 set positions of a bottle rack. Leaflets were infested by placing 5-10 adult whiteflies on 2 leaflets/entry in small leaf cages for 24 or 48 hrs. Adult mortality was determined after 24 & 48 hrs and instar counts were taken after 14 & 21 days. Second generation reproduction was determined by placing the 2 leaflets with the highest number of 3rd & 4th instar larvae in a petri-dish and recording adult emergence over a 5-18 day period. Some of the hybrids were more resistant and others were more susceptible than the *L. esculentum* parent. Resistance was manifested in greater adult antibiosis, reduced number of developed larvae and reduced adult emergence.

## 114 (PS VI)

## ALSTROEMERIA CARBOHYDRATE PARTITIONING

David Graper and Will Healy\*, Department of Horticulture, University of Maryland, College Park, MD 20742

Non flowering *Alstroemeria* 'Regina' plants were divided into aerial components: stems and apical and basal leaves or underground components: rhizome, storage roots, stele and fibrous roots. Samples were collected from distal and proximal ends of the rhizome to allow comparisons between structures of different ages. Ethanol soluble sugars were extracted and measured using HPLC. Starch was degraded to glucose using amyloglucosidase and measured.

There were no age differences in the starch, total soluble sugar (TSUGAR) or total soluble carbohydrates (TCHO) in the rhizome or aerial portions of the plant. There was a preferential partitioning of starch, sucrose, TSUGAR and TCHO to underground plant parts. The storage roots were the primary sink for the stored carbohydrates. Stems contained large concentration of glucose while fructose was found in storage roots and old stems. Sucrose was found primarily in old steles and storage roots. Starch was partitioned almost exclusively into the storage roots with no difference due to age of the storage root. Up to 42% of the TCHO in the old storage roots was composed of a carbohydrate which co-chromatogrammed with melezitose using HPLC.

## 115 (PS VI)

## TEMPORAL PATTERN OF GROWTH IN ALSTROEMERIA

Scott Aker and William Healy\*, Department of Horticulture, University of Maryland College Park, MD 20742

*Alstroemeria* 'Regina' and A. 'Orchid' Linn. plants were grown in rhizotrons to facilitate non-destructive observation of shoot, rhizome, and storage root growth. In plants grown at 21/11 C or 21/21 C day/night temperatures under either 8 hr night interruption or an 8 hour short days, storage root growth was favored by cool (11 C) night temperatures and long days. The seasonal patterns of storage root and rhizome growth were inversely related to the seasonal pattern of shoot growth. Growth of shoots and rhizomes followed a cyclic pattern. The cycles of shoot and rhizome growth were in phase with each other until the plants resumed vegetative growth due to high soil temperature. At this point, the cycles of shoot and rhizome growth were shifted out of phase with each other. Thinning shoots by 60% resulted in delay and damping out of the peak of storage root growth; the cyclic growth of storage roots was disrupted when plants were thinned by 60% such that the cycles of active storage root growth were delayed by 1 week.

116 (PS II)  
EFFECT OF CALCIUM CHELATORS ON WALL STRUCTURE AND DEEP SUPERCOOLING OF XYLEM PARENCHYMA OF PEACH  
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The pit membrane of xylem parenchyma of peach plays an important role in deep supercooling. Enzyme hydrolysis of xylem tissue indicated that the pit membrane is rich in pectin. The objective of the present study was to determine if removal of calcium from the cell wall would effect deep supercooling by loosening the cell wall. Current year shoots of 'Loring' peach were infiltrated with oxalic acid, EGTA, or sodium phosphate buffer for 24-48 hours and then prepared for either ultrastructural analysis or differential thermal analysis. The use of 5-50 mM oxalic acid resulted in a distinct reduction in the size of the low-temperature exotherm (LTE) with increasing concentration. Oxalic acid also produced a loosening and swelling of the pit membrane. The use of EGTA (100 mM) or NaPO<sub>4</sub> (150 mM) produced only a slight shift in the LTE to warmer temperatures when compared to fresh tissues. Heat treatments (30-100°C) also resulted in a gradual shift of the LTE to warmer temperatures. The data indicate that cross-linking of pectins may play a role in defining the pore structure of the pit membrane and that this area of the cell wall plays an integral role in deep supercooling of peach wood.

117 (PS III)  
HERITABILITY ESTIMATES OF THERMODYNAMIC IN LETTUCE

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Lettuce (*Lactuca Sativa* L.) seeds imbibe water but most fail to germinate. This phenomenon now termed "thermodormancy" is prevalent in arid and semiarid climates like the southwest desert regions. Inheritance studies of thermodynamism were performed in two lettuce cultivars, Dabora (Dutch butterhead) and PI 251245 (a plant introduction from Egypt). Dabora will germinate up to 27°C and PI 251245 up to 36°C. Reciprocal crosses were made. Pericarp color was used as a marker to determine successful crosses. Dabora X PI 251245 was used to estimate the heritability of thermodynamism by germinating seed from 10 F3 families and 160 F4 families at "high" temperatures.

118 (PS VIII)  
EFFECTS OF GROWTH CONDITIONS AND RIPENING ON PLASTID AND MICROSOMAL MEMBRANE LIPID COMPOSITION IN BELL PEPPER FRUIT  
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Plastids and microsomal membranes were isolated from pericarp tissue of mature green and red-ripe tell pepper fruit harvested from greenhouse and field grown plants. The lipid composition of these membrane fractions changed far more with ripening of field grown than greenhouse grown fruit. Also, the phospholipid (PL), free sterol (FS), steryl glycoside (SG) and acylated steryl glycoside (ASG) content of microsomes and plastids from both green and red fruit were very different under the two growing conditions. Total steryl lipids (TSL = FS + SG + ASG), and the TSL/PL ratio, increased in microsomes and decreased in plastids with ripening. These changes were much greater in field grown fruit. The ASG/SG ratio decreased with ripening in both membrane fractions, under both growing conditions. Ripening and growth conditions affected the phospholipid and sterol composition in plastids much more than in microsomes. Lipid changes associated with the chloroplast - chromoplast transformation were similar in field and greenhouse grown fruit, including an increase in the galactolipid/PL ratio. Future studies will assess how differences in membrane lipid composition affect postharvest storage life of the fruit.

119 (PS II)  
EFFECTS OF PRECONDITIONING TEMPERATURE TREATMENTS ON BACTERIAL ICE NUCLEATION

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Epiphytic populations of ice nucleation active (INA) bacteria responded differently to preconditioning temperature treatments depending on plant species. Ice nucleation activity of inoculated tomato (*Lycopersicon esculentum* Mill.), squash (*Cucurbita pepo* L.), and

cucumber (*Cucumis sativus* L.) seedlings was not affected by preconditioning temperature treatments of 7, 21, or 33°C for 3 hr prior to freezing assays. In contrast, preconditioning at 33°C for 3 hr prior to assay decreased mean freezing temperatures of inoculated pine shoots compared with preconditioning at 5°C. Preconditioning treatments of pine shoots had a greater effect on freezing temperatures when tissues were submerged in water during treatment. Cucumber seedlings responded similarly regardless of whether they were exposed to preconditioning treatments with dry surfaces or in a saturated environment. Preconditioning temperatures had a greater effect on ice nucleation activity of bacterial suspensions than on plants harboring INA bacteria.

120 (PS III)  
INHERITANCE OF PLANT REGROWTH AFTER HARVEST AND YIELD RELATED CHARACTERS IN GUAYULE

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Guayule (*Parthenium argentatum* Gray), a rubber-producing shrub of the southwest desert, is currently being investigated to increase rubber yields through a breeding and genetics program in Arizona. Reproduction and seed formation in guayule results from facultative apomixis with estimated occurrence between 85 and 95%. The degree of environmental and genetic influences on traits related to yield is unknown. Four guayule lines propagated both from cuttings and from seeds were compared to estimate the environmental influence on yield components. Yields were also examined on plants regenerated after harvest by clipping plants above ground level. The plants' ability to regenerate after a clipping harvest is dependent on both environmental and genetic influences. The yields were compared to unclipped plants of the same line.

121 (PS VIII)  
SWEET CHERRY QUALITY AFTER STORAGE IN MODIFIED ATMOSPHERE PACKAGING

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Modified Atmosphere Packaging (MAP) in combination with temperature control were investigated for quality enhancement of sweet cherries (*Prunus avium* L.). 'Bing', 'Lambert' and 'Rainier' cherries (1 kg/pkg/rep) were wrapped in 1 of 3 different MAP films (5,303; 8,900 and 11,286 cc/sq M/24 hrs of O<sub>2</sub> and stored at 0 or 4°C for 3 weeks. Post-storage evaluations included both fruit and stem color, fruit firmness, weight loss, soluble solids, titratable acidity, bruising and pitting valuations, respiration rates and visual assessment. MAP films helped maintain fruit and stem color, and fruit firmness. Whereas weight loss and bruising were reduced. Visual assessment was best with fruit in MAP film packages. There was little change in soluble solids and titratable acidity among fruit in the different MAP films. Control (unwrapped) fruit had considerably higher soluble solids and titratable acidity than wrapped fruit. This difference in soluble solids and titratable acidity between control and MAP fruit was associated with a considerable weight loss in the control fruit. Respiration rates of the fruit varied among the different MAP films and was cultivar dependent. Fruit stored at 0°C had better quality after 3 weeks of storage than fruit stored at 4°C.

122 (PS II)  
ROOT GROWTH OF MAGNOLIA GRANDIFLORA HORT. 'ST. MARY' AFTER EXPOSURE TO ROOT-ZONE TEMPERATURE TREATMENTS  
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Root growth of *Magnolia grandiflora* Hort. 'St. Mary' was studied for 16 wk after an 8-wk exposure period to 30°, 34°, 38°, or 42°±0.8°C root-zone temperature (RZT) treatments applied 6 hr daily. Immediately after the RZT treatment period, total root length was similar for trees exposed to 30°, 34°, and 38°C and was reduced 45% at 42° compared to 38°C. For weeks eight and 18 of the post-treatment period, response of total root length to RZT was linear. Total root length of trees exposed to 28°C was 247% and 225% greater than those exposed to 42°C RZT at week eight and 16, respectively. Root dry weight from the 42°C RZT treatment was 29% and 48% less than 38° and 34°C RZT treatment, respectively, at week eight. By week 16, root dry weight as a function of RZT had changed such that the 42°C RZT was 43% and 47% less than 38° and 34°C RZT, respectively. Differences in root growth patterns between weeks eight and 16 suggest that trees were able to overcome the detrimental effects of the 38°C treatment whereas growth suppression by the 42°C treatment was still evident after 16 wk. Previous exposure of tree roots to supraoptimal RZT regimens may have long-term implications for suppressing growth and lengthening the establishment period of trees in the landscape.

## 123 (PS III)

ALLOZYME INHERITANCE AND DIVERSITY IN SOUR CHERRY  
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Starch gel electrophoresis was employed to study inheritance and diversity of allozyme loci in a sour cherry ( $2n=4\times=32$ ) germplasm collection. Segregation data was collected for alcohol dehydrogenase (ADH), glucose phosphate isomerase (GPI), isocitrate dehydrogenase (IDH), leucine amino peptidase (LAP), malate dehydrogenase (MDH), peroxidase (PX) (cathodal activity), phosphoglucumutase (PGM), 6-phosphogluconic dehydrogenase (6-PGD), and shikimate dehydrogenase (SKDH).

Data suggest that alleles can be assigned to many of the enzyme systems being studied: ADH, GPI, IDH, LAP, PGM, and 6-PGD. Most loci are diallelic and often exhibit the unbalanced heterozygous condition. MDH, PX, and 6-PGD are highly polymorphic. Progeny segregation data fit disomic inheritance models, indicating that sour cherry is an allotetraploid.

## 124 (PS VIII)

COMPARISON OF METHODS FOR GASSING TOMATOES WITH ETHYLENE  
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Mature green tomatoes (*Lycopersicon esculentum* Mill. cv. 674) were gassed with 160 to 275  $\mu\text{l/liter}$  ethylene, depending upon the experiment, from either a Catalytic Generator or gas cylinder. Tomatoes were evaluated during subsequent ripening for fruit color development and taste. The combined results of two triangle difference taste tests indicated that the panel could tell a slight difference in taste of tomatoes based on gassing method. However, panelists did not reveal a strong preference for tomatoes from either method or consistently mention a certain characteristic that made the two groups of tomatoes different. Gas chromatographic analyses of the effluent from the Catalytic Generator indicated that several compounds other than ethylene were present.

## 125 (PS II)

VARIATIONS IN COLD HARDINESS CHARACTERISTICS AMONG PRUNUS SPECIES

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Flower buds of 20 *Prunus* species representing 4 subgenera were collected during winter and spring of 1989-90. Buds were preconditioned at  $+3^\circ$  or  $7^\circ\text{C}$  to test their minimum hardiness level (MHL) or the rate of hardiness increase. DTA revealed that most of the *Prunus* species have flower primordia that supercool. The subgenus *Padus* have racemose inflorescences and do not deep supercool during dormancy. *P. besseyi*, *P. nigra* and *P. americana* had small exotherms between  $-22^\circ$  and  $-27^\circ\text{C}$  while *P. davidiana* and *P. subhirtella* had larger exotherms at higher temperatures. Exposure of flower buds to  $-7^\circ\text{C}$  shifted LTE to lower temperatures and/or reduced the size of LTE, which became undetectable for many species including *P. nigra* and *P. americana*. *P. davidiana* and *P. subhirtella* increased hardiness by  $6^\circ/\text{day}$  at  $-7^\circ$  while dormant. Deacclimation coincided with an increase in  $\text{LTE}_{50}$  and the development of xylem vessel elements in the bud axis, calyx and filaments as indicated by dye movement. *P. davidiana* was the least hardy species and required only 700 chill units to satisfy the chilling requirement, while *P. nigra* and *P. americana* had LTE average of  $-26^\circ\text{C}$  at MHL and required over 1000 chill unit accumulation.

## 126 (PS III)

RFLPS FOR IDENTIFICATION OF GRAPE CULTIVARS

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DNA from 9 cultivars and 5 'Pinot noir' clones were isolated with either the Delaporta or cTAB methods. Twenty five  $32\text{P}$  label led cloned probes were constructed with the pUC18 plasmid and Hind-III digested 'Pinot noir' DNA. Standard methods of isolation and labelling were used. The probes were tested for efficacy of 'fingerprinting' the 14 selections. rDNA and chloroplast a/h binding protein probes were also tested. The

non-specific probes were not found to be useful as they bound to an excess number of sites and could not be removed from the southern blots, rendering them useless for further analysis. Grape specific probes bound at multiple sites, indicating that multiple fragments were incorporated into the plasmid vectors during library construction. With the greater variability observable with these multi locus probes, significant polymorphism was observed between cultivars, including 'Cabernet sauvignon' and 'Pinot noir' which were not distinguishable with GPI or PGM isozymes. Variability between clones of 'Pinot noir' was observed with several probes, indicating that these selections are different. No variability had been observed at isozyme loci of the 'Pinot noir' clones

## 127 (PS III)

GENETIC DIVERSITY IN WALNUTS USING RFLP MARKERS

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RFLP probes were developed to determine the degree of genetic diversity both within and between 12 walnut species (*Juglans* spp.), including the widely cultivated English walnut (*J. regia*). One to three kilobase DNA fragments from Pst I digested *J. regia* nuclear DNA were cloned using the vector pUC18. Inserts corresponding to low copy number walnut genomic sequences were used to assess the genetic variability among walnut species. Extensive polymorphism was found between species and limited polymorphism within species. The inheritances of the RFLP loci are being analyzed to provide a genetic basis for the polymorphisms detected and to establish a RFLP based linkage map in walnuts

## 128 (PS VIII)

THE EFFECTS OF POSTHARVEST MANAGEMENT ON THE PILLOWY DISORDER IN CUCUMBER (*CUCUMIS SATIVUS* L.)

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A fruit anomaly, pillowy (P), has been identified in processing cucumber. This physiological disorder has been shown to be accelerated by water stress.

A series of experiments were conducted to determine postharvest handling procedures which minimize the appearance of pillowy after induction by water stress. Isogenic lines evaluated in RCB design with 3 replications were subjected to water stress during fruit enlargement. Fruits were then subjected to various storage temperatures and times before hydrocooling to  $8^\circ\text{C}$ . Cucumbers were then fresh pack processed and evaluated for % pillowy after 12 weeks.

The postharvest control treatment (2 days,  $26^\circ\text{C}$ , 60% RH) produced 32%P to 51%P in fruit subjected to stress and 23%P to 39%P in unstressed fruit. In the optimal postharvest treatment (1 day,  $26^\circ\text{C}$ , 60% RH, then hydrocool to  $8^\circ\text{C}$ , 2 days,  $15^\circ\text{C}$ , 85% RH) fruits from stress plants exhibited 23%P to 39%P and those from nonstress plants showed 13%P to 26%P. Fruits from miniature leaf lines exhibited higher percent (37%) P ratings when compared to normal leaf lines.

## 129 (PS II)

MEFLUIDIDE IMPROVED THE DEVELOPMENT OF TERMINAL FLOWER BUDS OF CHILLED PEPPER PLANTS

Jing-fen Chen, Paul H. Li\* and David W. Davis, Department of Horticultural Science, Univ. of Minnesota, St. Paul, MN 55108

Exposure of young pepper plants to chilling temperatures delays the development of terminal flower buds to flowering during post-stress growth. Degree of adverse influence depends on chilling intensity, exposure duration and varietal sensitivity. 'Ma Belle' pepper plants were grown in a greenhouse (GH) during winter months on the St. Paul campus. No supplemental lighting was provided. When plants were at the 2- to 3- leaf stage, they were foliar sprayed with mefluidide (Technical grade) at 0, 5, 10 and 15 ppm. One day after treatment, some plants were transferred from GH to a cold room ( $3^\circ\sim 4^\circ\text{C}$  day/night) with 12-h photoperiod. Treated plants remaining in the GH served as the control. Plants were chilled for 1, 2, 4 and 6 days and then brought back to the GH for post-stress growth and development observation. Treated and untreated plants grown in the GH showed no difference in days to flowering, and reached 50% flowering at about 62 days after treatment. When untreated plants were chilled for 1, 2, 4 and 6 days, they showed a delay of 8, 18, 30 and 34 days, respectively, to flowering. If not killed, as compared to the control. The long delay to flowering was due to the injury of the terminal flower buds. After 4 and 6 days of chilling, most terminal flower buds were killed. However, when plants were treated with mefluidide and subsequently chilled days to flowering were significantly shortened. A difference of 10-12 days was observed between chilled untreated plants and chilled treated plants. Concentrations of 5 to 15 ppm were equally effective in protection against chilling.

## 130 (PS III)

**SOMACLONAL VARIATION IN SOLANUM AND LYCOPERSICON GENOTYPES.** Chang-Yeon Yu\* and John Masiunas, Department of Horticulture, University of Illinois, Urbana, IL 61801.

The objective of this study was to investigate the chromosomal and genotypic variation in regenerated plants of *Solanum* and *Lycopersicon*. Calli of *Lycopersicon peruvianum* genotypes PI199380, PI26345, PI251301, and LA1373, along with *Solanum ptycanthum* were transferred onto media consisting of MS salts with Gamborg vitamins. The shoots formed were rooted in vitro and transferred to greenhouse soil. Actively growing root tips were harvested and pretreated, fixed, hydrolyses and stained. Pollen mother cells were fixed in propionic alcohol solution and stained with aceto-carmin. The number of chromosomes were counted. The greatest variation was in *Solanum ptycanthum* with chromosome numbers ranging from 18 to 60 ( $2n=24$ ). Progeny analysis for 12 somaclones of *Solanum ptycanthum* was done by selfing for two generations. Morphology, shoot height, and weight were determined in each generation. The amount of variation differed among the somaclonal lines.

## 131 (PS III)

**PLANTLET REGENERATION FROM ACIFLUORFEN-TOLERANT CELL LINES OF SOLANUM PTYCANTHUM AND LYCOPERSICON PERUVIANUM.** Chang-Yeon Yu\* and John Masiunas, Department of Horticulture, University of Illinois, Urbana, IL 61801.

Frable callus of *Solanum ptycanthum* and *L. peruvianum* PI199380 clone 149 were subcultured on liquid Murashige and Skoog salts and Gamborg Vitamin medium with 2,4-D (1mg/l) until a fine suspension of cells was obtained. The suspension cultured cells were then plated on selection medium. Twenty-five acifluorfen-tolerant cell lines of *Solanum ptycanthum* and fourteen tolerant *Lycopersicon peruvianum* cell lines were obtained by a stepwise increase in concentration of acifluorfen. Acifluorfen-tolerant cell lines were transferred on to regeneration media with the herbicide. Shoot regeneration differed depending on the cell line and acifluorfen concentration, ranging from 0 to 37 plants per calli. As acifluorfen concentration increased in the regeneration media, the number of shoots and shoot height decreased. There was a wide range of variation in shoot morphology, which depended on the cell line.

## 132 (PS VIII)

**GERMINATION OF PENSTEMON SEED USING SEED SCARIFICATION AND SEED STRATIFICATION**

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*Penstemon*, a U.S. native plant/wildflower, is increasing in use as a landscape plant. *Penstemon* species are commonly propagated by seeds. However, species vary greatly in percent seed germination.

Seeds from eight sources of *Penstemon* germplasm were given cold moist stratification periods of either 0, 2, 4, 6, 8 or 10 weeks. One-half of the seed for each treatment was scarified with sandpaper. The study was repeated twice, once in 1989 and once in 1990.

Seed germination varied with species, and with the length of stratification. Greatest germination occurred at the 6, 8 and 10 week periods and the lowest germination occurred with no stratification. There were also differences between species in percent germination. Average percent germination was highest for *P. gracilis* and lowest for *P. haydenii*. There was a significant species  $\times$  stratification interaction. Seed scarification did not influence germination as much as seed stratification in these studies

## 133 (PS II)

**THERMOTOLERANCE AND ANTIOXIDANT ACTIVITY OF MOTH BEAN SEEDLINGS AS INFLUENCED BY 24-EPIBRASSINOLIDE** Abha Upadhyaya, Tim D. Davis\*, and Narendra Sankhla, Texas A&M University Research and Extension Center, 17360 Coit Rd., Dallas, TX 75252-6599

Seeds of moth bean (*Vigna aconitifolia* Jacq. Marechal cv. Jaadia) were germinated in the presence of 0, 0.1, 1, or 2  $\mu$ M 24-epibrassinolide (EBL). After 72 h, cotyledons were excised and the seedlings exposed to 22 or 48 °C for 90 min. At 48 °C EBL increased total electrolyte, K<sup>+</sup>, and

sugar leakage relative to the untreated control. Following exposure to 48 °C, EBL-treated seedlings had higher malondialdehyde concentrations than controls indicating that EBL enhanced high temperature-induced lipid peroxidation. At 48 °C, EBL increased ascorbic acid oxidase activity and decreased superoxide dismutase activity relative to the control. Taken together, these data do not support the hypothesis that brassinosteroids confer thermotolerance to plants. On the contrary, EBL increased high temperature-induced damage and reduced the activity of some antioxidant systems that may protect against stress-induced cellular damage.

## 134 (PS V)

**FIELD PRODUCTION OF HERBACEOUS PERENNIAL CUT FLOWERS** Leonard P. Perry, Department of Plant and Soil Science, University of Vermont, Burlington, VT 05405

Mean yields (stems per plant) of 5 randomly selected plants from a block of 15 were determined for each of 13 species of 2-year old herbaceous perennials. Mean yields of *Achillea filipendulina* 'Coronation Gold' of 4 randomly selected plants, in each of 4 replicates in a randomized c-o-replete block design, were determined over 3 years for 3 spacings. The most consistent yields over the period, and highest in years 1 and 3, were from 60cm spacing between plant centers, with yields from 90cm and 30cm highly variable. In year 2, stems were graded by length with most stems 40 to 49cm at 30cm and 90cm spacings (19 and 46 stems) and 50 to 50cm at 60cm (27 stems). As stems per plant increased from 30 to 72 for 30cm to 90cm spacing, respectively, stems per 30cm<sup>2</sup> decreased from 30 to 8. Vase life was greatest (9 days) for stems in Oasis preservative, with less in Floralife (8 days), tap water (7 days), or distilled water (5 days). Flowers 10 days older prior to cutting lasted an average 2 days less.

## 135 (PS VIII)

**FRUIT AGE AND SEED EXTRACTION PROCEDURES AFFECT GERMINABILITY OF CUCURBIT SEEDS**

Haim Nerson, Department of Vegetable Crops, Agricultural Research Organization, Neve Ya'ar Experiment Station, P.O. Haifa, Israel.

Fruits of four cucurbit crops, cucumber, melon, watermelon, and squash, were harvested 25, 35 and 45 days past anthesis (dpa) and their seeds were extracted immediately or after 10 or 20 days of pre-extraction storage. Upon extinction, the seeds were subjected or not subjected to fermentation, washing and drying. The effects of these procedures on terminability was examined immediately after extraction or after up to 48 months of storage. Cucumber, melon and watermelon reached full germinability by 35 dpa, but squash required a longer period. Fermentation and drying were important for improving terminability of immature seeds of cucumber, melon and watermelon. Fermentation had a deleterious effect on immature squash seeds, but drying and washing improved terminability of squash seeds. Washing of cucumber, melon and watermelon seeds increased the rate of germination but not the percentage. Pre-extraction storage had a positive effect on terminability but was less effective than leaving the fruit on the vine for a comparable period of time. The seed coat completed its growth earlier than did the embryo.

## 136 (PS II)

**EFFECTS OF IRRIGATION WATER SALINITY AND LIMING RATE ON CATION UPTAKE BY QUEEN PALMS**

Timothy K. Broschat\*, University of Florida, FLREC, Ft. Lauderdale, FL 33314

Queen palms (*Syagrus romanzoffiana*) were grown in containers of sand to determine the effects of irrigation water salinity and liming rate on cation uptake by the plants. Dolomite was incorporated at rates of 0, 3, or 6 kg/m<sup>3</sup>. Within each lime rate palms were irrigated with a solution of NaCl and CaCl<sub>2</sub> (molar ratio =5Na:1Ca) at conductivities of .25, 1, 2, 4, or 6 dS/m. Plant height and dry weight and leaf Mg were decreased with increasing irrigation water salinity, whereas leaf Ca was increased at higher salinities. Leaf Mn and Zn increased, then decreased as salinity was increased. Leaf Ca and Mg increased with increased lime, but leaf Mn and Cu were decreased by increasing the lime rate. Leaf K increased, then decreased as lime rate was increased.

## MUTANT SEEDLINGS OF CONIFERS FROM WITCHES' BROOMS

Waxman, Sidney. Department of Plant Science, University of Connecticut, Storrs, CT 06269-4067

Seedlings obtained from mutations on conifer trees exhibit populations of dwarf shrubs. The general characteristics of the shrubs often differ from progeny to progeny. The most obvious difference between progenies is in annual rates of growth, with some showing growth rates 10 or more times greater than the slowest growing group. Differences that appear within each progeny include needle length, foliage coloration, branching habit and plant form. As a consequence, many interesting forms have been produced and named that are miniature, dwarf, and intermediate in size.

Variations in form include plants that are columnar, rounded, spreading, and weeping. Whereas variation in foliage color include blue-green, green, and gold.

## 138 (PS VIII)

## OBJECTIVE MEASURES OF CHILLING INJURY IN GRAPEFRUIT

T. G. McCollum\* and R. E. McDonald, U.S. Department of Agriculture, ARS, 2120 Camden Road, Orlando, FL 32803

Storage of 'Marsh' white seedless grapefruit (Citrus paradisi Macf.) for 2 weeks at 5°C resulted in the development of chilling injury (CI). Electrolyte leakage from chilled fruit did not increase significantly until CI had become severe, and was therefore considered to be a poor index of CI. In contrast to electrolyte leakage, respiration and ethylene evolution were consistently higher in chilled than in nonchilled fruit, even prior to the onset of visual symptoms of CI. Respiratory rates ranged from 8.0 to 10.7 and 4.6 to 6.7 ml/kg/hr in chilled and nonchilled fruit, respectively. Ethylene evolution was not detected from nonchilled fruit, whereas chilled fruit produced from 45.6 to 249.3 ml/kg/hr ethylene. Ethylene production was maximum following 2 weeks at 5°C. Results of this study indicate that increases in electrolyte leakage do not occur until considerable tissue damage has occurred, whereas stimulation of respiration and ethylene evolution occur early in the development of CI.

## 139 (PS II)

## CRYOPRESERVATION OF RUBUS FLORAL BUDS IN LIQUID NITROGEN

Jianying Gu\*, Michele Warmund, and Milon George, Department of Horticulture, University of Missouri, Columbia, MO 65211

Floral buds of 'Royalty' purple raspberry and 'Heritage' red raspberry were used to develop a cryopreservation method without loss of viability. The effects of prefreezing (PF), cooling rate, thawing rate, and cold storage at -7°C were tested. No survival was observed in samples immersed directly in LN<sub>2</sub>, whereas 'Heritage' and 'Royalty' had 90 and 97% survival after holding the samples at -22°C ('Heritage') or -18°C ('Royalty') for one week before immersion in LN<sub>2</sub>. In all cases, fast thawing resulted in a higher survival rate than slow thawing. Rapid cooling rate decreased the buds survival in LN<sub>2</sub>, however the effect was diminished when the samples were stored at the PF temperature for one week. The effect of both thawing and PF storage became less critical with bud dehydration. Differential thermal analysis (DTA) was conducted on buds without any PF treatment and buds that were subjected to PF and cold storage. DTA samples that did not receive PF exhibited LTEs, while LTEs were absent in samples subjected PF for one week. Thus, the slow removal of intracellular water to extracellular ice appears to be associated with subsequent survival of Rubus buds in LN<sub>2</sub>.

## 140 (PS V)

## MINERAL UPTAKE BY ROOTS OF TROPICAL ORCHIDS

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The kinetics and efficiency of uptake of minerals (ammonium, nitrate, phosphate, potassium, calcium and magnesium) by roots of three tropical orchid genera (Aranda, Dendrobium and Oncidium) were studied and compared. Mericloned plantlets of these three orchids were cultured in solid Vacin and Went medium. The pattern of mineral uptake by orchids of these three orchid genera was

similar. There was a preferential uptake of ammonia over nitrate. Rapid nitrate uptake by roots began only after 3 weeks in culture. Initial uptake of potassium, calcium and magnesium were rapid but the residual levels of these minerals either remained constant (Mg, PO<sub>4</sub>) or increased (K, Ca) after the 4th week. The % of uptake for ammonium nitrate, phosphate, potassium, calcium and magnesium over 9 weeks of culture was 60-76%, 24-28%, 12.8-27%, 17-30%, 17-26% respectively for the three orchid genera. A good correlation between growth of plantlets and uptake was observed.

## 141 (PS VIII)

## CELL WALL SYNTHESIS IN 'RUTGERS', RIN AND NOR TOMATO FRUIT

Elizabeth J. Mitcham\*, Kenneth C. Gross, and Timothy J Ng, USDA/ARS, Hort. Crops Quality Lab., Beltsville, MD 20705 (EJM, KCG) and Dept. of Horticulture, University of Maryland, College Park, MD 20742 (EJM, TJN)

Cell wall synthesis during development and ripening of 'Rutgers', rin and nor tomato (*Lycopersicon esculentum* Mill.) fruit was quantified by monitoring incorporation of <sup>14</sup>C into outer pericarp cell walls after pedicel injection of (U-<sup>14</sup>C)-sucrose. Fruit color (Hunter "a" and "b" values) and firmness (Instron) were also monitored. <sup>14</sup>C-Incorporation continued throughout development and ripening in 'Rutgers' cell walls and exhibited a transient increase from late mature-green to the turning stage. Incorporation of <sup>14</sup>C into cell walls of rin pericarp tissue was similar to 'Rutgers' at 20 days post-anthesis (DPA) (immature-green) but decreased to a level similar to red 'Rutgers' fruit by 35 DPA. Incorporation of <sup>14</sup>C into nor pericarp cell walls was low throughout the experimental period (20 to 75 DPA). In contrast to previous reports, rin and nor pericarp tissue exhibited a decrease in firmness of the outer pericarp. However, the rate of softening was slower than in 'Rutgers'. Pericarp tissue from rin and nor fruit at 70 and 75 DPA, respectively, resisted compression as much as pink 'Rutgers' pericarp tissue.

## 142 (PS II)

## OSMOREGULATION IN YOUNG JOJOBA SEEDLINGS

Y. Rasoolzadegan. Dept. of Horticulture, Isfahan University of Technology, Isfahan, Iran.

The possibility of osmotic adjustment to salinity in Jojoba was studied in a sand culture system. After being established, 2 Wks old seedlings were exposed to 1/2 strength hoagland's solution plus NaCl salt to make up -0.7, -0.4, -0.6, -0.8, & -1 MPa. Shoot & leaf elongation, components of  $\Psi_{leaf}$ , proline accumulation, & inorganic salts were determined every 24 hour for 9 days. Shoot & leaf length were reduced at -0.8 and -0.4 MPa respectively. Osmotic adjustment occurred only above -0.8 MPa at the rate of 0.21 If MPa/day. Total inorganic salts in whole plant increased with a decrease in solution  $\Psi_s$ . However, above -0.8 MPa excess Na & Cl ions were excluded from the leaves & accumulated within the roots, while K/Na ratio remained higher above -1 MPa. The selective uptake of K ions seems a possible mechanism for osmotic adjustment in Jojoba. Accumulation of Na & Cl ions under -1 MPa correlated with occasional pale green discoloration & tip-burn of leaves. Although the accumulation of proline was considerable at & below -0.8 MPa, but did not play a significant role in osmoregulation.

## 143 (PS V)

GROWTH AND PHOTOSYNTHESIS OF *MAGNOLIA GRANDIFLORA* HORT. 'ST. MARY' IN RESPONSE TO CONTAINER VOLUME AND SHIFTING TREATMENTS Chris A. Martin\*, Dewayne L Ingram, and Terri A. Nell, Department of Environmental Horticulture, IFAS, University of Florida, Gainesville, FL 32611

Trees were grown for 2 years as a function of three container volumes (10, 27, and 57 liter) the first year and six shifting treatments (10 liter both years, 10 to 27 liter, 10 to 57 liter, 27 liter both years, 27 to 57 liter, or 57 liter both years) the second year when containers were spaced 120 cm on center. Height and caliper were greatest for magnolias grown in 27- or 57-liter containers both years. Caliper was greater for trees shifted from 10-liter containers to the larger container volumes compared to trees grown in 10-liter containers both years. Trees grown in 10-liter containers both years tended to have few roots growing in the outer 4 cm at the eastern, southern, and western exposures in the grow medium. During the second year, high air and growth medium temperatures may have been primary limiting factors to carbon assimilation during June and August. Using large container volumes to increase carbon assimilation and tree growth may be even more important when daily maximum air temperatures are lower during late spring or early fall compared to midsummer.

#### 144 (PS VIII)

##### THE ANESTHETIC NITROUS OXIDE PROLONGS STORAGE LONGEVITY OF LYCHEE AND LONGAN SEED

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Seeds of the recalcitrant species *Litchi chinensis* and *Euphoria longan* were stored in humid conditions at 8-10°C under three different atmospheres: air, 80% nitrous oxide (N<sub>2</sub>O)/20% oxygen, and 100% nitrous oxide. The combination of anesthetic and oxygen extended storage longevity of both species. Oxygen was required for maintenance of viability; seeds stored under 100% N<sub>2</sub>O lost germinability at the most rapid rate. Lychee seeds retained 92% of control germination after 12 weeks under 80% N<sub>2</sub>O/20% O<sub>2</sub>, while those under air lost 56% viability. Longan seeds lost all viability after 7 weeks under air, yet retained 70% of their control germination under 80% N<sub>2</sub>O/20% O<sub>2</sub>. The combination of anesthetic and oxygen atmospheres could provide a new approach to recalcitrant seed storage.

#### 145 (PS II)

##### REDUCING CHILLING INJURY AND DECAY OF GRAPEFRUIT BY FUNGICIDES APPLIED AT HIGH TEMPERATURE

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The fungicides thiabendazole (TBZ) or imazalil were applied at 1 g-liter at 24 or 53°C to 'Marsh' and 'Redblush' grapefruit (*Citrus paradisi* Macf.) to reduce fruit susceptibility to chilling injury (CI) and decay. There was more CI and decay on 'Marsh' grapefruit than on 'Redblush'. CI was found to be lower in grapefruit that had been dipped at 53°C than at 24°C. CI was higher after water dips without fungicide. Imazalil was found to be more effective in reducing CI than TBZ. Fungicides reduced decay at both temperatures, and imazalil was better than TBZ. Results of this study confirm the benefits of high-temperature fungicide treatments for maintaining grapefruit quality and indicate some benefits of high-temperature fungicide treatments for reducing CI.

#### 146 (PS V)

##### SHOOT GROWTH STIMULATION DURING SOFTWOOD CUTTING PROPAGATION OF *BETULA* AND *FORSYTHIA*

Norman Pellett\* and David Heleba, Department of Plant and Soil Science, University of Vermont, Burlington VT 05405

Gibberellic acid (GA) and benzyladenine (BA) were evaluated for stimulating shoot growth during rooting of softwood cuttings of two species whose propagation causes bud dormancy. Cuttings of *Betula papyrifera* Marsh. and *Forsythia mandschurica* Uyeki 'Vermont Sun' were treated with 4 levels of GA or 2 levels of BA while rooting in a polyethylene-covered chamber humidified by fog. GA treated *Forsythia* produced longer shoots, but did not increase the percentage of cuttings producing new shoots (overcoming dormancy). GA treatments of *Betula* at 1000, 2500, and 5000 ppm resulted in reduced shoot growth and caused death of most cuttings. BA at 1000 ppm in a solution of ethanol, DMSO, and water was detrimental to cuttings.

#### 147 (PS VIII)

##### CHARACTERISATION OF FRUIT DEVELOPMENT AND RIPENING IN SOURSOP AND BREADFRUIT

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Growth and development were characterised in two compound tropical fruit, soursop, *Annona muricata* L., and breadfruit, *Artocarpus altilis* (Park.) Fosb. The growth curves of both fruit were typically sigmoidal as determined by length, diameter, fresh weight and dry weight measurements. Soursop showed biphasic development with the flower/fruit remaining in an apparent resting state for some 12 weeks post anthesis before entering the second or true phase of growth leading to maturity. For both fruit, size increase extended over a 3 month period. Maturity indices were derived for each fruit and simple

post harvest changes in texture, respiration and ethylene evolution investigated. Storing either fruit under refrigeration down to 14°C significantly extended storage life though at temperatures below this chilling injury was evident.

#### 148 (PS II)

##### UNTANGLING LEAF INJURY NOMENCLATURE IN THE LITERATURE

M.E. Conley, Horticulture Dept., UNL, J.C. Pair, KSU Horticulture Research Center, Wichita, KS 76233 and E. T. Paparozzi\*, Horticulture Dept., University of Nebraska, Lincoln, NE 68583

During 1989, leaves of 3 cultivars of *Acer saccharum* were sampled from a cultivar trial. The purpose was to anatomically investigate development of leaves and incidence of foliar injury due to tatter. Previously, certain cultivars had been observed to be more predisposed to tatter than others. However, more injury symptoms than just tatter occurred. An extensive literature search revealed that definitions for each type of injury varied and often conflicted.

In this poster, photographs of various injuries plus the terms and definitions deemed most representative of what was observed will be presented. Terms explored will include tatter, windburn, sunburn, scorch and scald. Also, a separate symptom which may prompt creation of a new term, will be presented. This injury appears to be part of, but could be separate from, the etiology of leaf tatter. This new term must be considered carefully as preliminary results suggest that tatter does appear to be linked to anatomical differences among cultivars. A questionnaire soliciting opinions/reactions to the confusion in the literature, these terms, and the new term(s) will be featured. Hopefully, this will help resolve the leaf injury nomenclature dilemma.

#### 149 (PS V)

##### EFFECT OF TRANSPLANTING PETUNIA PLUGS AT DIFFERENT STAGES OF DEVELOPMENT

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Petunia seeds of 'White Cascade', 'Red Flash', and 'Red Madness' were sown in 406 plug trays on the same date. The first transplanting occurred when the plants could be removed from the cells without root damage. Subsequent transplanting occurred for four weeks. The first transplanting of 'White Cascade' flowered two weeks earlier than the second while the third transplanting was one week behind the second. 'Red Flash' flowered two weeks earlier for the first transplanting. There was no effect on time to flower for the 'Red Madness'. The highest fresh and dry weights corresponded to the earliest flowering transplants. Optimum growth and development for most petunia cultivars was obtained with the earliest transplanting without root damage.

#### 150 (PS VIII)

##### ARTICHOKE SEED GERMINATION RESPONSES TO CHILLING AND GROWTH REGULATOR TREATMENTS

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Three trials were conducted in 1989 to evaluate the effects of chilling, freezing, growth regulator, and acid scarification treatments on the seed germination of two artichoke varieties. Soaking seed in a 500, 1000, or 2000 ppm ethephon solution for 5 minutes significantly increased the rate and uniformity of germination. Chilling, freezing, gibberellin, and cytokinin treatments did not affect germination rate. Freezing moistened seed and acid scarification significantly delayed germination. Ethephon treatments did not affect subsequent seedling development.

#### 151 (PS II)

##### HEATED IRRIGATION FOR FROST PROTECTION

J. David Martsolf\*, Fruit Crops Department IFAS, University of Florida, Gainesville, FL 32611

An undertree sprinkler [Maxijet] irrigation system designed to deliver 42 to 80 l/hr to each of 570 citrus trees (planted 6.1 × 6.1 m, heights of the larger uniform trees: 2m) was fed through an irrigation water heater [Aquaheat]. The heater added up to a megawatt of heat to the irrigation pipeline by the combustion of diesel fuel. A porous orchard cover (59m × 64m × 3.6m; 0.38ha) sheltered one of six plots of similar size in a citrus orchard on the University of Florida campus in Gainesville. Two border zones, one 3 rows deep on the north border and one on the west tapering from 2 rows on the north to a single row on the south end reduce the edge effect for a total orchard area of 2.12 ha. A minicomputer based data acquisition system provided observations of temperature, wind speed and direction made as frequently as one scan per minute. The effect



of the orchard cover, the undertree irrigation, the heated irrigation and combinations of these three methods on the orchard microclimate will be shown in graphs and diagrams of observations taken during the freezes of February 24-26, and December 24-25, 1989. A diagram of the potential effect of water temperature on latent heat transport in the orchard will be discussed as will be problems with documentation of dew point temperature with chilled mirrors under freezing conditions.

#### 152 (PS V)

##### THE EFFECT OF CHILLING TIME AND PHOTOPERIOD ON FLOWERING OF STANDARD DWARF BEARDED IRIS.

Victoria E. Anjichi\* and Edmund J. Holcomb, Department of Horticulture, The Pennsylvania State University, University Park, PA 16802.

The flowering of Dwarf Bearded Iris as a potted plant requires knowledge of the effect of chilling time and photoperiod on the plant. An experiment was conducted to determine what combination of these two factors would lead to flowering. The treatments were chilling time (0, 4, and 8 weeks) and irradiance treatment (short day, long day, and HID lighting). Iris rhizomes were potted into 6 inch pots, kept moist and placed in a 4°C cooler for the various lengths of time. These were then transferred to the different irradiance levels and allowed to flower in the greenhouse.

The plants that received 8 weeks of chilling flowered earliest, followed by those that received 4 weeks of chilling. The plants that were placed under HID lighting flowered earlier than those that were placed under long day light treatment. The plants that received short day light treatment did not flower except for those that received 8 weeks of chilling.

#### 153 (PS VIII)

##### FUMIGATION WITH CHLORINE DIOXIDE FOR PROLONGING THE POST HARVEST LIFE OF GRAPES AND BLUEBERRIES

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Table grapes cvs. Flame Seedless, Black Monukka and Canadice and blueberries cvs. Bluecrop and Northland were exposed to chlorine dioxide (ClO<sub>2</sub>) gas under laboratory conditions. Chlorine dioxide was generated chemically. Grapes were fumigated in a plexiglass chamber with ClO<sub>2</sub> for 30 minutes, packed in TKV lugs with Botrytis inoculum planted among the clusters and stored at 0° C for 8 weeks. Blueberries were consumer packed with 5, 10, and 15 gr. Absorb (ClO<sub>2</sub> generator) in Tyvek sachets, enclosed in pillow-pak bags and stored at 0° C for 75 days and at 20 or 30° C for 16 days.

At periodical intervals, moisture loss, decay and quality parameters were evaluated. Chlorine dioxide caused bleaching and skin injury around the calyx on blueberries but not on grapes. Decay was reduced with ClO<sub>2</sub> treatment but moisture loss increased in blueberries. We could store grapes for two weeks without fungal growth. Storage for longer periods necessitated treatment with higher concentrations of ClO<sub>2</sub>, which were not generated under our laboratory conditions.

#### 154 (PS II)

##### HEAT STRESS TOLERANCE AND SEASONAL DEVELOPMENT IN CONIFER SEEDLINGS

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It is not known when changes in primary direct heat stress tolerance of conifer seedlings occur in relation to other seasonally changing physiological parameters. This information should be incorporated into nursery practices and the matching of genotypes to landscape sites. Greenhouse-cultured, container-grown Douglas-fir, Engelmann spruce, and ponderosa pine, were cold acclimated and reaclimated in growth chambers over 19 weeks. Direct heat stress tolerance of needles, cold hardiness, and bud dormancy were measured weekly. Douglas-fir and Engelmann spruce heat stress tolerance increased with the development of new growth through one complete growth cycle, i.e., bud break, maturation, cold hardening, dehardening, and bud break the following growing season. Ponderosa pine differed in that new needles had intermediate tolerance, and fully cold hardy needles were the most intolerant. In none of the species did the timing of changes in heat stress tolerance coincide consistently with changes in cold hardiness or bud dormancy.

#### 155 (PS V)

##### USE OF GROWTH REGULATORS TO ENHANCE LATERAL BRANCHING OF ALGERIAN IVY (HEDERA CANARIENSIS L.)

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Three node stem cuttings of Algerian Ivy *Hedera canariensis* were sprayed with growth regulators to incipient runoff under greenhouse conditions. The results demonstrated that the combination of BA + GA<sub>4+7</sub> (Promalin) promoted branching of Algerian Ivy better than applications of BA or GA<sub>4+7</sub> alone. Plants treated with Atrinal developed more shoots per node than those treated with GA<sub>4+7</sub>, BA, or Promalin. Increasing concentration of Atrinal from 0 to 3000 ppm, also reduced branch length and leaf number for both pinched and unpinched plants. 2,3,5-triodobenzoic acid (TIBA) significantly increased the branching of Algerian Ivy, although plant shape was not commercially acceptable due to epinasis of the foliage.

#### 156 (PS VIII)

##### IMMUNOLOGICAL COMPARISON OF PECTINESTERASE ISOENZYMES FROM TOMATO

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Pectinesterase is present in green tomato fruit and increases several-fold during ripening. Several isoenzymes of pectinesterase can be separated by chromatography of tomato extracts on DEAE-Sephadex A-50. The predominant isoenzyme in most tomato cultivars including Better Boy has been designated PE IV. This isoenzyme accounts for most of the increase in total pectinesterase during ripening of these cultivars. The fruit of some cherry tomato cultivars such as Pixie and Short Red contain some PE IV, but the major isoenzyme is PE III which occurs only in these cultivars. PE III and PE IV were isolated from ripe fruit of Short Red and Better Boy, respectively, to further characterize differences between the isoenzymes. PE III binds more strongly to cation exchangers, indicating that it is more basic than PE IV. The molecular weights were estimated by gel filtration to be 26,900 and 25,100 for PE III and PE IV, respectively. Polyclonal antibodies were raised against the two enzymes. Cross reactivity of the enzymes with the antibodies indicates that PE III and PE IV are immunologically identical.

#### 157 (PS II)

##### RELATIVE WATER REQUIREMENTS OF SIX GROUND-COVER SPECIES.

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Non-turf ground-covers occupy a significant portion of the landscape, and understanding their water requirements is important when water conservationism being practiced. Six groundcover species (*Baccharis pilularis* 'Twin Peaks', *Drosanthemum hispidum*, *Vinca* major *Gazania* hybrid, *Potentilla tabernaemontani* and *Hedera helix* 'Needlepoint') representing a range of observed water needs were evaluated under different levels of irrigation based on percentages of real-time reference evapotranspiration.

Treatments of 100%, 75%, 50% and 25% of ET<sub>o</sub> were applied during 1989 while treatments of 50%, 40%, 30% and 20% of ET<sub>o</sub> were applied during 1990. Plant performance ratings in the first year indicated that 50% of ET<sub>o</sub> was the minimum treatment which resulted in acceptable plant aesthetics for all species except for *Drosanthemum* which performed equally well at each treatment. Significant differences in performance did occur among and within species at the different treatments. Results from 1990 will reveal which species might maintain aesthetic appearance at irrigation levels between 50% and 20% of ET<sub>o</sub>. These results will be presented and discussed in terms of their significance to species selection and total landscape irrigation management.

#### 158 (PS V)

##### IN VITRO EMBRYOGENESIS DERIVED FROM LEAF CALLUS OF 'TIFFANY' ROSE

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Friable callus from leaf disks of *Rosa hybrida* 'Tiffany' was initiated within two weeks under dark conditions and 25°C on Murashige and

Skoog (MS) medium supplemented with 4 mg.liter<sup>-1</sup> 2,4-D. Callus was then transferred into MS medium containing 3 mg.liter<sup>-1</sup> 2,4-D. Within four weeks, rhizogenesis occurred on the callus surface.

The rhizogenic callus was subculture on MS medium plus 3 mg.liter<sup>-1</sup> 2,4-D every 4-6 weeks. Within six months from initial culture, somatic embryos were developed on the aging callus in darkness.

Transfer of the aging callus with somatic embryos into 1/2 MS medium containing 1 mg.liter<sup>-1</sup> kinetin and maintaining it under 46  $\mu$  E m<sup>-2</sup>s<sup>-1</sup> light for 16 hrs. resulted in greening of the somatic embryos.

#### 159 (PS VIII)

##### THE USE OF CHITOSAN COATING TO EXTEND THE STORAGE-LIFE OF TOMATO FRUITS.

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The effect of chitosan coating on the respiration rate, ethylene production and quality attributes of tomatoes stored at 20°C under high humidity-regular atmosphere was investigated. Chitosan coating reduced significantly the respiration rate and ethylene production of tomatoes, with a greater effect at higher concentration. In addition coating modified the internal microatmoaphere of fruits. Furthermore, coated fruits were firmer, higher in titratable acidity, less decayed and their change in color proceeded at a slower rate than the control.

In conclusion chitosan coating delayed senescence and prolonged storage life of tomatoes, without affecting their market quality by acting as diffusion barrier for gases.

#### 160 (PS II)

##### COLD HARDENING VS ABA AS A PRETREATMENT FOR MERISTEM CRYOPRESERVATION

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Cold hardening is an effective method for conditioning meristems for cryopreservation. ABA plays a role in hardening and produces increased hardness in suspension cultured cells. This study was designed to determine if growth, in vitro, on ABA (5 $\times$ 10<sup>-4</sup> M) for one week, would substitute for one week of cold hardening, and if ABA would provide additional conditioning when added in combination with cold hardening treatments. In vitro plantlets of *Rubus* spp. were grown for one week with or without cold hardening and with or without ABA. Meristems from these plants were frozen at 0.8C\* min<sup>-1</sup> to -35 C, then plunged into LN<sub>2</sub>, thawed, and plated on recovery medium. One month after thawing, cold-hardened plants with and without ABA treatment had recovery rates of up to 83%. Survival of plants grown at room temperature ranged from zero to 8% and zero to 28% for plants grown on ABA at room temperature. At the rates tested, ABA is less effective than cold hardening in conditioning apical meristems of in vitro *Rubus* plants for cryopreservation and provides no additional protection to cold-hardened meristems.

#### 161 (PS V)

##### POINSETTIA CULTIVARS RESPOND DIFFERENTLY TO MOLYBDENUM DEFICIENCY

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Nine cultivars were grown in a 1:1 sphagnum peat and perlite medium with no limestone or trace element fertilizer. Fertilizer solutions of 300 ppm N and K (calcium nitrate and potassium nitrate) and 24 ppm Mg were applied at every watering. Solutions supplied all trace elements and either 0 or 1 ppm Mo. Moderate to severe foliar symptoms of Mo deficiency developed on 'Annette Hegg Brilliant Diamond' and 'Eckespoint Lilo' with 0 ppm Mo. Symptoms did not occur with 1 ppm Mo. No Mo deficiency symptoms developed on the other 7 cultivars which included 'Supjibi', 'Gutbier V-17 Angelika', 'Peace Regal Velvet', and 'Cheers!'. With 0 ppm Mo these cultivars generally maintained higher levels of nitrate reductase enzyme activity and lower tissue nitrate levels than the 2 showing symptoms.

#### 162 (PS VIII)

##### MICROSOMAL MEMBRANE CHANGES IN IRRADIATED CAULIFLOWER DURING STORAGE

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Cauliflowers (*Brassica oleracea*) were irradiated at 0, 2, and 4 kGy and stored 8 days at 13°C. Development of yellow color and browning of the inflorescence, increase in membrane electrolyte leakage and reduction of protein recovery in microsomal membranes were observed over the storage period. Changes in membrane free fatty acids, lipid phosphorus content, peroxydation level, and fatty acid composition of polar lipids also occurred. These results indicate an important modification of cellular membranes. The direct effect of gamma rays on membrane lipids via free radical production and subsequent destabilization of the lipid bilayer during storage could be responsible for earlier onset of senescence.

#### 163 (PS II)

##### THE EFFECTS OF FILM-FORMING ANTITRANSPIRANTS ON LEAF WATER RELATIONS OF BEDDING PLANTS

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The effectiveness of antitranspirant type and concentration on the leaf water relations of *Salvia splendens* F. 'Firebird and *Petunia*  $\times$  hybrida Juss. 'Comanche'. Two film-forming antitranspirants, Cloud Cover and Folicote, were tested at three different concentrations in two different environments. The leaf water potential, stomatal conductance, and relative water content were evaluated. Transpiration per unit vapor pressure deficit and stomatal conductance for both crops decrease slightly but there was no trend with respect to the film type, environment or concentration rate. The leaf water potentials and relative water content did not show significant difference after antitranspirant application. In order for antitranspirant application to be of benefit to the growth of herbaceous plants, a more durable coating that remains semipermeable would have to be utilized.

#### 164 (PS V)

##### TEMPERATURE DURING EARLY DEVELOPMENT AFFECTS PLANT MORPHOLOGY OF *BEGONIA* $\times$ *HIEMALIS*

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The effect of temperature during the initial long day period on morphology and plant dry weight was determined for *Begonia*  $\times$  *hiemalis* 'Hilda'. Multistem cuttings were planted in 10 cm pots and grown at 13°, 16°, 19°, 22°, 25° or 28°C. The day length was 16 hours at an irradiance level of 280  $\pm$  20  $\mu$ mol-m<sup>-2</sup>s<sup>-1</sup>. After 21 days, the plants were moved to a greenhouse maintained at 20°  $\pm$  2°C and short days of 10 hours at 125  $\pm$  20  $\mu$ mol-m<sup>-2</sup>s<sup>-1</sup>. The plants were grown under short days for 14 days and then moved to a day length of 16 hours. At data collection 21 days later (56 days from planting), plant height averaged 185 mm for plants initially grown at 13°, 16°, 19° or 22°C while plants originally grown at 25° and 28°C were 40 and 78 mm shorter than plants started at lower temperatures. The mean number of shoots was 4 on plants exposed to 16°, 19°, 22° or 25°C during early development and decrease to 3 shoots for plants grown initially at 13° or 28°C. The average flower number on the main shoot was similar for plants first exposed to low and intermediate temperatures but decreased rapidly to 0 for plants with early exposure to 28°C. Plants in treatments with early temperatures of 19° or 22°C had the largest above ground dry weight at an average 460 mg.

#### 165 (PS VIII)

##### INFLUENCE OF PRODUCTION NITROGEN LEVEL AND BENZYLADENINE ON POSTHARVEST CHARACTERISTICS OF *Rosa* $\times$ *hybrida* 'Meijikatar'

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*Rosa*  $\times$  *hybrida* 'Meijikatar' plants were fertilized on weekdays with Hoagland's solution at 100, 200, or 300 mg-liter<sup>-1</sup> nitrogen. Prior to simulated shipping, plants were treated with benzyladenine at 0, 25, 50, or 100 mg a.i. -liter<sup>-1</sup>. Plants were subsequently paper sleeved and stored in cardboard boxes in darkness at 16 C for 5 days.

On the day of harvest, plant height and number of flowers

per plant were not affected by production nitrogen level. After removal from simulated shipping, total chlorophyll was increased in the lower leaves of plants grown at higher nitrogen rates and treated with higher rates of benzyladenine. Three and five days after removal from simulated shipping, the least percent leaf chlorosis was observed on plants treated with higher rates of cytokinin, but there was no effect of production nitrogen regime.

#### 166 (PS II)

##### SEASONAL CHANGE IN FREEZING TOLERANCE OF RED RASPBERRY CLONES IN THE PACIFIC NORTHWEST

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Seasonal changes in freezing tolerance of stems and buds of *Rubus idaeus* L. 'Chilliwack', 'Comox', 'Meeker', 'Skeena' and 'Willamette' clones were measured from November through March of 1988-1989 and 1989-1990. Eight additional clones were tested in 1989-1990. Canes were harvested from the field, cut into two-bud samples and subjected to controlled freezing tests. Samples were seeded with ice, held at -2°C overnight and then frozen at 3°C/hour. Viability was estimated by visual browning. Vascular tissue at the base of the buds was the least freeze tolerant tissue in these samples. Results of both the 1988-1989 and 1989-1990 freezing tests, indicated 'Meeker' and 'Willamette' cold acclimated more slowly in the fall than 'Chilliwack', 'Comox' and 'Skeena'. However, in the spring, 'Willamette' and 'Meeker' were slower to lose freeze tolerance than the other three clones.

#### 167 (PS V)

##### LEACHING OF SIX PHOSPHATE SOURCES FROM A PINE BARK CONTAINER MEDIUM

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Research reports documenting phosphorus leaching from soilless container media has changed commercial nursery phosphorus fertilizing practices. However, rhododendron growers are concerned that phosphorus levels are adequate as plants begin setting flower buds in July and August. Medium solution of 10 to 15 ppm P are recommended. Five replicated leachate samples were collected from 6 phosphate sources for 11 weeks following surface application to 2 container grown rhododendron cultivars. Each fertilizer source was blended to an analysis of 14.0N-11.2P-5.0K except a 14.0N-0P-5.0K control. Phosphate sources included Diammonium Phosphate, Triple superphosphate, Sulfur coated Diammonium Phosphate, Sulfur coated triple superphosphate, and a commercial rhododendron sulfur coated fertilizer. With the exception of control, all treatment leachate phosphorus levels ranged from 180 to 145 ppm two days and 85 to 75 ppm one week after application. All sources ranged from 45 to 10 ppm weeks 2-5 and were lower than 10 ppm weeks 7-11. Leachate levels of the control were below 10 ppm at all sample times. Bud set and foliar P levels were different among phosphate treatments, but growth index measurements were not significant.

#### 168 (PS VIII)

##### LEAF BLACKENING IN *PROTEA NERIIFOLIA* R. BR.

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Leaf blackening of *Protea neriifolia* is a common postharvest problem which renders flowers unsalable. Previous reports suggest that depletion of carbohydrates in source leaves caused by transfer of carbohydrates to the strong flower sink may be a major cause. Flowering stems of *P. neriifolia* were harvested in California under standard conditions and shipped to Baton Rouge, La. Upon arrival, the stems were re-cut (1 cm.), the number of leaves counted and the diameter and height of the flowers measured. Stems were transferred to 1 liter deionized distilled water containing 50 ppm hypochlorite, and 0.5% sucrose or no sucrose, and placed in a growth chamber (25°C) either with 12 hrs light (120 µmol/m<sup>2</sup>/s), or 24 hrs darkness. Number of leaves 10% black, flower diameter and height, and carbon exchange rates were measured every two days over a 16 day interval. Soluble and insoluble nonstructural carbohydrates were determined and assimilate export rate was estimated for each sampling day. Stems placed in the light maintained healthy foliage while those in the dark had 77-100% of their

leaves 10% black by day 8. Flower and leaf quality in the light treatment were superior with addition of sucrose to the vase solution. Influence of treatments on carbohydrate metabolism in relation to leaf blackening and flower development will be discussed.

#### 169 (PS II)

##### EFFECT OF SODIUM CHLORIDE ON PHOTOSYNTHESIS AND WATER RELATIONS OF REDBUD

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Redbud (*Cercis canadensis*) is known to be very susceptible to injury by road de-icing salts. The purpose of these experiments was to measure the effects of sodium chloride on net CO<sub>2</sub> assimilation (A), conductance (g), transpiration (E), and leaf area expansion (LAE) of hydroponically grown redbud seedlings. Eight week-old seedlings were exposed to 0, 4500, and 9000ppm NaCl in the hydroponic growth solution. A, g, E, and LAE were measured for seven consecutive days during treatment application.

A, g, E, and LAE all decreased with increased salt stress. By the seventh day, growth in NaCl at 4500 and 9000 ppm resulted in reductions in A from that of the control by 34% and 63%, respectively. For the medium treatment, g and E had decreased by 70% over control rates, and by 85% over control for the high treatment. For the 0, 4500, and 9000ppm treatments, total leaf area increased by 68%, 46% and 28%, respectively, over the seven days of the experiment.

Further experiments will examine the effect of treatments on whole plant transpiration, water potential and osmotic potential and will measure the ability of seedlings to recover from treatments of various duration.

#### 170 (PS V)

##### GROWTH CONTROL OF *BOUGAINVILLEA SPECTABILIS* 'SCARLETT O'HARA'

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*Bougainvillea spectabilis* 'Scarlett O'Hara' is an extremely fast-growing plant that can require frequent pruning during production. The purpose of this study was to evaluate the effectiveness of uniconazole and daminozide in controlling growth.

Plants growing in 3.8-liter containers were pruned 3 days before uniconazole (SUMAGIC .05%L) or daminozide (B-NINE SP) was applied. The treatments were 1) uniconazole foliar spray at 0, 50, 100, 150, or 200 ppm, 2) uniconazole drench at 0.5, 1.0, 2.5, or 5.0 mg ai/plant, and 3) daminozide foliar spray at 0, 2500, 5000, 7500, or 10,000 ppm. Uniconazole and daminozide primarily inhibited increase in the width of bougainvillea; height was only repressed at the high rates of uniconazole or daminozide (only 10,000 ppm). The 200 ppm uniconazole spray and the low drench rates reduced the growth rate for 3 to 5 weeks. Drenches of 2.5 or 5.0 mg ai/plant resulted in excessive growth reduction.

#### 171 (PS VIII)

##### GERMINATION OF THREE WILDFLOWER SPECIES AFTER SEED PRIMING

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Wildflower species are being used for highway median vegetation, land restoration programs, and revegetation of industrial sites. Rapid, uniform germination is critical to establishment of new stands. Seed priming techniques may increase the potential for successful establishment under adverse environmental conditions. The influence of seed priming of *Gaillardia puchella*, *Monarda citriodora*, and *Coreopsis tinctoria* on germination at 10° and 25° C was investigated. Seeds of the three species were placed in five levels of oxygenated KNO<sub>3</sub> (3.5, 3.25, 3.0, 2.75, and 2.5%) solutions, or a control of oxygenated distilled water for 144 hr. Germination percentage and rate of germination (MRG) were improved for *Gaillardia* and *Coreopsis* at 10° and 25°C. Germination percentage and MRG for *Monarda* were not effected by priming at 25°C, but both were significantly improved at 10°C. The optimum concentration of KNO<sub>3</sub> for greatest rapid germination was dependent on the seed variety. These results suggest that in most cases wildflower germination percentage and rates were improved by the priming procedure.

172 (PS II)

#### CHARACTERIZATION OF ICE FORMATION IN BLUEBERRY FLOWER BUDS

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Examination of both frozen specimens and -5C freeze-fixed buds showed that ice crystals were not uniformly distributed in blueberry flower buds. Localized freezing was also evidenced by detection of multiple freezing events using differential thermal analysis (DTA). Upon cooling, an initial exotherm occurred just below 0C and coincided with ice formation in adjacent woody tissue. Multiple low temperature exotherms (LTE), which have been reported to correspond with the freezing of individual blueberry florets (Bierman, et al. 1979. ASHS, 104(4):444-449), occurred between -7C and -28C. The presence and temperature of LTEs was influenced by cooling rates and whether buds were excised. LTE temperatures did not correlate with hardiness of buds frozen under field-like conditions. Results suggested that DTA of excised buds was not an appropriate method for determining hardiness.

173 (PS V)

#### CHRYSANTHEMUM RESPONSE TO TIMING OF PACLOBUTRAZOL AND UNICONAZOLE SPRAY APPLICATION

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Spray applications of uniconazole (UC) or paclobutrazol (PB) were applied 0, 2, or 4 weeks after pinching *Dendranthema grandiflora* (Tzvelev). 'Bright Golden Anne' cuttings planted 4 per 15 cm pot. Cuttings were controlled to 3 shoots each, averaging 5.4 and 14.9 cm at 2 and 4 weeks, respectively.

Final height was affected interactively by week of application and chemical treatment. Treatment at pinch caused less stem elongation than later treatments, probably due to persistence of PB and UC activity until flowering. At week 4, 67% of stem elongation had already occurred and, therefore, less retardation was possible. Of the 4 triazole treatments, PB at 30 mg l<sup>-1</sup> (20 ml per pot) applied at pinch produced heights similar to daminozide 5000 mg l<sup>-1</sup> applied at 2 weeks. PB at 60 mg l<sup>-1</sup> gave similar height control as UC 15 mg l<sup>-1</sup>. UC 30 mg l<sup>-1</sup> treated plants were shortest regardless of treatment timing, averaging 16.9 cm applied week 2.

Other growth data was pooled for week of application and for chemical treatment since there was no interaction. Flowering was delayed 2 days and flower dry weight was reduced up to 26% by treatment at pinch compared to later treatments. Flower diameter was only minimally affected by treatments.

174 (PS VIII)

#### IMPROVEMENT IN SEED GERMINATION IN PURPLE CONEFLOWER (*ECHINACEA PURPUREA*) AFTER COLD STRATIFICATION OR OSMOTIC PRIMING. N. Wartidningsih\* and Robert L. Geneve, Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington, KY 40546.

Germination was evaluated in six seed lots of purple coneflower purchased from four different seed companies. Standard germination percent ranged from 28% to 90% depending on the seed lot. For seed collected in 1989, seed size and stage of development of the seed at harvest could not account for the wide variability in seed germination observed in the purchased seed lots. preconditioning the seed with either cold stratification (10°C for 10 days) or osmotic priming (PEG or salt solution at -5 bars for 5 days) increased the rate of germination and the overall percent germination for all seed lots and dramatically improved germination in the poor germinating seed lots. Preconditioning appears to overcome either a shallow physiological dormancy or compensates for seeds with poor vigor or quality. In either case, seed preconditioning drastically improved seed germination (rate and percent) in greenhouse and field tests for purple coneflower.

175 (PS II)

#### FACTORS INDUCING DESICCATION TOLERANCE IN CELERY SOMATIC EMBRYOS

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Desiccation tolerance of somatic embryos is a key factor for production of dry synthetic seeds. In celery (*Apium graveolens* L.) desiccation tolerance can be enhanced by optimization of culture duration, ABA application, or sucrose concentration in the embryo production medium. Morphologically mature embryos cultured for 10 days have shown higher desiccation tolerance than those cultured for 8 days, indicating that biochemical changes occur without any noticeable morphological changes. Application of ABA (1 µM) for the last two days of the embryo production cycle was critical for inducing desiccation tolerance; ABA application for the last four days had some additional beneficial effect. Desiccation tolerance was

further enhanced by increasing the sucrose concentration of the embryo production media from 3% to 7% for the last two days. Increased desiccation tolerance achieved with optimal harvest timing and ABA application were associated with increased endogenous proline and γ-aminobutyrate, and reduced glutamine.

176 (PS V)

#### SHOOT PROLIFERATION OF CERCIS CANADENSIS L. IN VITRO USING THIDIAZURON AND BENZYLADENINE

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Selected cultivars of redbud (*Cercis canadensis* L.) and related *Cercis* species are usually propagated by grafting, but the success rate is low and other problems can be associated with the rootstock. Micropropagation would solve many of these problems. Shoots from a 25 year-old redbud were collected during July 1989 and established in vitro on modified MS medium. Shoots proliferated poorly with lower concentrations of Benzyladenine (BA) and high concentrations of BA caused shoot tip abortion. Similar problems with red-silver hybrid maples were solved by the use of Thidiazuron (TZ) in the medium. Established 2 cm redbud shoots were treated with TZ (0, 0.05, and 0.1 µM) and BA (0, 1 and 5 µM) in a factorial arrangement to test for shoot proliferation. After 4 weeks of the treatment with 0.1 µM TZ and 5 µM BA, mean shoot number was 4.6 compared to 1.1 shoots with no BA or TZ in the medium. Further experiments with rooting treatments will be presented.

177 (PS VIII)

#### CHILLING OF PEACH SEEDS, SEEDLINGS AND CUTTINGS

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Correlations were made between the responses of seeds, physiologically dwarfed seedlings and dormant cuttings to similar chilling treatments. Seed germination correlated highly with growth of physiologically dwarfed seedlings and shoot growth of dormant cuttings. Emergence and seedling growth correlated poorly with germination, growth of physiologically dwarfed seedlings and shoot growth of dormant cuttings. Thus, germination was a better seed predictor of the mature peach chilling response than emergence or seedling growth. Growth of dwarfed seedlings correlated highly with shoot growth of dormant cuttings. The anomalous leaf condition of peach seedlings may have confounded seedling growth after seed chilling, but was not a problem when the chilling treatment was provided to physiologically dwarfed seedlings. The dormancy release mechanisms that promoted seed germination, growth of physiologically dwarfed seedlings and growth of dormant cuttings were similar.

178 (PS II)

#### WHOLE PLANT MECHANISMS OF AMMONIUM INDUCED INCREASES IN WATER STRESS AND SENSITIVITY OF MUSKMELON TO NaCl

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Two mechanisms that reduce water and salt stress, respectively, are an increase in root hydraulic conductivity ( $L_r$ ) and reduction in Na and Cl absorption and transport to the leaf.  $\text{NH}_4\text{-N}$  decreased muskmelon  $L_r$  55-70% while under 100 mM NaCl stress and 40-50% in the absence of NaCl stress. A decrease in  $L_r$  increases the rate of water stress development as the transpiration rate increases. Although dry weight decreased about 70%, with  $\text{NO}_3\text{-N}$ , muskmelon remained healthy green, while with  $\text{NH}_4\text{-N}$  they became chlorotic and necrotic with a 100% and 25% increase in leaf blade Na and Cl compared to  $\text{NO}_3\text{-N}$ , respectively. Further investigation indicated that  $\text{NH}_4\text{-N}$  increased muskmelon sensitivity to NaCl through both an increased rate of net Na influx and transport of Na to the leaf. Since Na influx partitioning is controlled by mechanisms K/Na selectivity and exchange across membranes, the  $\text{NH}_4\text{-N}$  inhibition of K absorption may impair K/Na exchange mechanisms. Reduced K/Na selectivity or Na efflux are implicated as the source of the increased net Na influx with  $\text{NH}_4\text{-N}$ . The importance of K in preventing Na partitioning to the leaf was confined through removal of K from the nutrient solution thereby simulating the  $\text{NH}_4\text{-N}$ -induced gradual K depletion in muskmelon. Our work indicates that at a given level of water or NaCl stress,  $\text{NO}_3\text{-N}$  reduces the level of stress experienced by muskmelon through increasing  $L_r$  and reducing the net rate of Na influx and transport to the sensitive leaf blade. This avoidance mechanism should enable muskmelon plants fertilized with  $\text{NO}_3\text{-N}$  to tolerate greater levels of stress.

179 (PS V)

EFFECT OF UNICONIZOLE AND GIBBERELIC ACID ON WATER USE AND GROWTH OF ASIATIC JASMINE (*TRACHELOSPERMUM* × *ASIATICUM*) AND VINCA (*VINCA* × *MAJOR*)

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Uniconizole has great potential for use in both the landscape and nursery industry for improved plant quality, more efficient maintenance techniques, and increased water conservation. A study was conducted to evaluate the effects of uniconizole and methods of application on growth, development, and water use of asiatic jasmine and vinca. Treatments consisted of 1.25 mg A.I., 2.5 mg A.I., or 5 mg A.I. applied in a 25 ml spray or 25 ml soil drench. Another study was conducted to determine if the growth regulation effects could be overcome by direct application of GA. GA<sub>4</sub> and GA<sub>3</sub> were applied at rates of 2.5 mg A.I., 12.5 mg A.I., or 25 mg A.I. in a 25 ml solution after growth reduction had occurred. The 5 mg A.I. uniconizole spray and drench treatments were most effective in reducing growth and whole plant transpiration for asiatic jasmine and vinca respectively. Transpiration per unit leaf area was not reduced for any treatment except for asiatic jasmine at the highest drench rate.

180 (PS VIII)

GAS MIXTURES FOR BLUEBERRY PRESERVATION

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Blueberries were exposed to a series of atmospheric gas mixtures using an automated, computerized, gas-mixing, monitoring, controlling and recording system. Nitrogen was obtained from a PSA generator, O<sub>2</sub> from an in-house air compressor and CO<sub>2</sub> from compressed gas cylinders. Precise mixtures were made by introducing source gas streams into electronic gas-mixing valves where they were pre-mixed at desired concentrations and directed to fruit chambers. Gas mixtures giving maximum decay control and retention of harvest quality at 0°C were determined. Mixtures preserving fruit without causing fermentation or toxicity were also determined. Quality was retained in excess of 60 days at optimum gas levels. Increasing the fresh market period of blueberries with CA storage and prolonging shelf life and extending shipping distances with MA packaging appears promising.

181 (PS II)

CRYO-SEM OBSERVATION OF OCCLUSIONS IN STRAWBERRY HYDATHODES

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In previous work no difference was found in leaf water potential or solute potential between young guttating leaves and older non-guttating leaves of the same plant. This suggested that the absence of guttation in older leaves was associated with a plant resistance component in the hydathodes. Hydathodes of young, folded leaves contained water pores with various apertures and no signs of occlusion. In expanded, young leaves, production of epicuticular waxes and excretion of some substance through the pores was observed in the hydathode region. By the time leaves had fully expanded the hydathodes had become brownish. The combination of wax deposition and excreted substance had formed plates of solid material covering water pores. These observations suggest that deposition of substances on top of pores contribute to occlusion of water pores in old leaves.

182 (PS V)

UNICONIZOLE AFFECTS GROWTH AND WATER RELATIONS OF LIGUSTRUM

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Growth of ligustrum (*Ligustrum japonicum* 'Texanum') was controlled by the application of the growth regulator, uniconizole, at 3 mg A.I. per 7.6 liter pot. Seventy-nine days after application, growth regulated plants had shorter internodes, smaller stem diameters and reduced secondary branching and new leaf production. Differences in daily water use between the two treatments began to appear at the same time that differences in

growth became apparent. Total water use of treated plants was 13% less than the control. When daily water use was normalized on a leaf area basis, water use between treatments was similar, suggesting differences in total water use were primarily due to differences in leaf area. Under well-watered conditions, the sap flow rate in the main trunk of plants in both treatments ranged between 60 and 100 g h<sup>-1</sup>m<sup>-2</sup> of stem area. Leaf conductance, transpiration rate and water potential were also similar for treated and control plants.

183 (PS VIII)

IMPROVED HIGH TEMPERATURE SEED GERMINATION OF PANSY WITH SEED PRIMING

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*Viola tricolor* seed were exposed to aerated solutions of water or 300 or 400 mM NaCl for 0, 2, 4, 6, or 8 days. After priming treatments, seed were air dried, placed on moist filter paper in petri dishes, and set in dark growth chambers at 18 or 30°C for germination. Priming for 6 days in water increased germination of 'Crystal Bowl Yellow' seed from 80 to 88% when germinated at 30 °. Untreated seed germination was 92% at 18°. Priming for 6 days in 300 mM NaCl improved germination of 'Majestic Giant Blue' seed from 57 to 76% when germinated at 30°. Untreated seed germination was 80% at 18°. These data indicate that seed priming could be used to improve summer germination of a cool season annual. Priming increased germination at the higher than optimum temperature (30°) to levels similar to that for the optimum temperature (18°). However, the best priming solution depended on the cultivar.

184 (PS II)

RELATIVE COLD TOLERANCE OF FOUR UNBUDDED PISTACHIO SEEDLING ROOTSTOCKS

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Currently, the California pistachio industry relies upon 4 rootstock; *Pistacia integerrima*, *P. atlantica* and 2 different hybrids of *P. atlantica* × *P. integerrima*. Although observations have been made, no trials have established the relative cold tolerances of these rootstock. The above four rootstock were planted in June, 1989, in Shasta County, California. Each rootstock was repeated once within the 100 replications of the randomized complete block experimental design. The trees were unbudded. The lowest winter temperature of 14°F (-24°C) occurred in February, 1990. When the trees were rated for damage in April, 1990, *P. atlantica* displayed only 3% mild tip burn damage compared to 56% tip burn for *P. atlantica* × *P. integerrima* (commercially known as UCB #1), 79% tip burn for *P. atlantica* × *P. integerrima* (commercially known as Pioneer Gold I) and 95% severe dieback for *P. integerrima*. Five superior *P. integerrima* rootstocks, with no damage, were identified.

185 (PS V)

OPTIMAL CONDITIONS FOR ROOTING SHOOT CUTTINGS OF AZALEA (*RHODODENDRON* SP.) IN SOLUTION CULTURE

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Fundamental research on mineral nutrition of azalea has been restricted due to the lack of a model experimental system for growing azaleas in solution culture. The need to maintain a clean root system dictates that azalea cuttings be rooted in solution. A propagation system (HortScience 24:706) was used to root 10-cm long terminal shoot cuttings of azalea 'Delaware Valley White' under intermittent mist in a greenhouse. Cutting bases were dipped in 8,000 mg/liter K-IBA for 40 seconds before rooting. Rooting percentages after 7 weeks were 6, 10, and 50% for rooting solutions of tap water, modified 20% Hoagland solution, and 2mM CaCl<sub>2</sub>, respectively. After an additional 5 weeks the rooting percentage had increased to 83% in the 2 mM CaCl<sub>2</sub> treatment. Three other azalea cultivars were found to root much slower than 'Delaware Valley White'. Acclimatization of rooted cuttings to the normal greenhouse environment is essential to prevent leaf necrosis and is accomplished by gradually reducing the misting frequency prior to removal from under intermittent mist.

## FLOWER DEVELOPMENT OF MINIATURE POTTED ROSE PLANTS DURING SIMULATED SHIPPING

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Orange end Red Sunblaze miniature rose plants were forced to flower in a glasshouse in 10 cm pots. At harvest, flower stage (FST) 1 (tight bud), 2 (reflexed calyx), and 3 (petals starting to reflex) flowers were designated and tagged. The plants were then stored at 4, 16 or 28°C for 2, 4, or 6 days. Subsequent to the simulated shipping treatments, plants were evaluated in a simulated home interior environment (21° with 30  $\mu\text{mol m}^{-2}\text{sec}^{-1}$  cool-white fluorescent light). After summer forcing, flowers of both cultivars developed at least 1 FST during simulated shipping. Flower development increased as storage duration increased for FST 1 and 2, but storage duration did not affect development of FST 3 flowers. The higher the temperature the faster flowers developed, but development was less than 1 FST at 4°. After winter forcing, flowers developed less than 1 FST during simulated shipping. Flower development increased with increasing temperature. In summer, plants with FST 2 flowers could be shipped at up to 16°, but plants with FST 3 flowers should be shipped at 4°. In winter, plants can be shipped at up to 16° with FST 3 flowers.

## 187 (PS II)

## SHORT DAY TREATMENTS CAUSE EARLY DEHARDENING IN CONIFER SEEDLINGS

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Seventeen weeks old white spruce seedlings were hardened under 8 h or 16 h photoperiod for 28 d at 15°C (12 h) followed by 21 d at 3°C (8 h photoperiod) and 28 d at 0°C without light. Dehardening conditions were a 14 h photoperiod at 10°C for 21 d followed by 18 d at 20°C. Frost tolerance of whole plants and exised organs were measured at regular intervals. An earlier rehardening was observed for plants hardened under short day treatments. Similar results have been reported for black spruce in independent studies. Hypotheses to explain this phenomenon will be presented based on bud phenology, mineral content, sugar analyses and morphological data.

## 188 (PS V)

## EFFECT OF SUPPLEMENTAL AND PHOTOPERIODIC LIGHTING ON FLOWERING OF SATIN FLOWER

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Satin flower (*Clarkia amoena* ssp. *whineyi*; syn. *Godetia whineyi*) is a cool temperature, high light plant grown as a cutflower in Japan, Europe and California. In preliminary greenhouse cutflower and pot plant trials, satin flower plants flowered in 10-11 weeks when grown under 24hr supplemental HID lighting compared to 20-22 weeks under ambient winter conditions. In Sept. and Nov. 1989, satin flower plants were treated with the following supplemental and photoperiodic lighting treatments ambient light; SD (ambient day, black cloth 1600 to 800 HR); LD (ambient day, incandescent light 1600 to 400 HR, 5  $\mu\text{mol s}^{-1}\text{m}^{-2}$ ); SD-SPL (ambient day supplemented with 100  $\mu\text{mol s}^{-1}\text{m}^{-2}$  HPS, black cloth 1600 to 800 HR); LD-SPL (ambient day supplemented with 100  $\mu\text{mol s}^{-1}\text{m}^{-2}$  800 to 400 HR). Node number and days to flowering were significantly different between the treatments. Plants grown under LD-SPL flowered in 10 weeks and had 32 nodes, LD -13 weeks and 37 nodes (weak, spindly, few flowers), SD-SPL - 17 weeks and 70 nodes, SD - 21 weeks and 75 nodes. Strategies for supplemental lighting for greenhouse cutflower production will be discussed.

## 189 (PS VIII)

## QUANTITATIVE ANALYSIS OF FLAVOR VOLATILES AND OTHER PARAMETERS IN TWO TOMATO VARIETIES DURING RIPENING

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Whole tomato fruit (*Lycopersicon esculentum* Mill.), cvs. Sunny and Solarset, were analyzed at 5 different ripening stages for ethylene and CO<sub>2</sub> production. Homogenates from the same fruit were prepared for determination of color, flavor volatiles, sugars and organic acids. Of the flavor volatiles measured, only eugenol decreased during ripening in both varieties and 1-penten-3-one in 'Sunny' tomatoes. Ethanol, and trans-2-trans-4-decadienal levels showed no change or fluctuated as the fruit matured while all other volatiles measured (cis-3-hexenol, 2-methyl-3-butanol, vinyl guaiacol, acetaldehyde, cis-3-hexenal, trans-2-hexenal,

hexanal, acetone, 6-methyl-5-hepten-2-one, geranylacetone and 2-isobutylthiazole) increased in concentration, peaking in the later stages of maturity. Synthesis of some volatile compounds occurred simultaneously with that of climacteric ethylene and color. 'Solarset' fruit exhibited higher levels of sugars and all flavor components except ethanol, vinyl guaiacol, hexanal and 2-methyl-3-butanol in the red stage. There were no differences between these varieties for acids

## 190 (PS II)

CRYOPRESERVATION OF DORMANT GRAPE (*Vitis* sp.) BUDS. Virgil Esensee\*, Cecil Stushnoff, Dept. of Biochemistry, Colorado State Univ., Fort Collins, CO 80523, and Philip L. Forsline, USDA-ARS- NAA NYS AGR. EXP. STA. Geneva, NY 14456.

There is need for backup storage of clonally propagated plant cultivars of numerous taxa. Initial tests, using a protocol developed for dormant apple buds that includes desiccation and slow freezing prior to immersion in liquid nitrogen (-196 C), was not effective with 'Valiant' grape. Accordingly, replicates of *V. vinifera* 'Riesling', *V. riparia*, 'Valiant' and a *V. amurensis* × *riparia* cross were also tested for survival at -196 C, following desiccation to 25% & 18% water (fwb) and direct immersion into liquid nitrogen. Visual and electrolyte leakage ratings following nine days of dehydration in moist peat were used to assess viability. Direct immersion of desiccated samples resulted in survival for some buds of 'Valiant' and a *V. amurensis* × *riparia* cross. *V. riparia* showed some survival when field hydrated and at 25% water, while all buds desiccated to 18% survived. 'Riesling' did not survive desiccation, and was killed by all -196 C treatments. The apple protocol was partially effective, in combination with desiccation to 18% in 'Valiant' and *V. riparia*. This is the first report of grape bud survival in liquid nitrogen and more detailed studies are planned.

## 191 (PS V)

## THE EFFECTS OF PINCHING, SPACING, AND PLANTING DATE ON CUTFLOWER PERFORMANCE OF SATINFLOWER. Liliek S. Utami\*, Robert L. Geneve, Robert G. Anderson and Sharon T. Kester. Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington, KY 40546.

Satin flower (*Clarkia amoena* ssp. *whimeyi* - syn. *Godetia*) is a cool season native to the Western U.S. being studied for its potential use as a cutflower crop in Kentucky. In May 1989, plants of 'Grace Salmon' were transplanted to the field into black fabric mulch. A factorial experiment was conducted with three pinching treatment (no pinch, pinched early at the third node prior to transplanting, and pinched in the field at the third node after the first flower bud was visible) and at three spacings (15, 30 and 45 cm). There were significant main and interaction effects for both pinching and spacing for the number of flowering stems, stem length and plant diameter. However, no treatment combination consistently produced flowering stems of sufficient length for commercial quality. This may be due to the later spring planting date and hot weather in 1989. In an attempt to increase flower stem length, *Godetia* 'Grace Salmon' plants have been transplanted on April 10, 25 and May 10. Plants will be pinched in the greenhouse or grown without pinching at 45 or 15 cm spacing, respectively. The effect of supplemental lighting and long days during transplant production will also be considered.

## 192 (PS VIII)

## PHYSIOLOGICAL AND CELL WALL METABOLIC RESPONSES OF GRANNY SMITH APPLES TO LOW OXYGEN STORAGE.

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Commercially grown Granny Smith apples were stored at 0°C in air or 1% O<sub>2</sub>, and 2 sets of samples were taken every 4 weeks over a 28 week period. One set was immediately analysed for weight loss, firmness, color, soluble solids, pH and titratable acidity. Alcohol-insoluble substances were analysed for starch, water-soluble uronides, water-insoluble uronides, cellulose and neutral sugars. The second set of samples was kept in air at 20°C for an additional week, during which respiration and ethylene production rates were measured, prior to the above analyses. Storage in 1% O<sub>2</sub> led to the improved maintenance of firmness, reduced respiration and ethylene production rates in ambient air, and a reduced content of water-soluble uronides, suggesting a reduced degree of hydrolysis. The correlation between firmness and water-soluble uronide content was not very strong. The predominant neutral sugars present in the wall were arabinose and galactose, and activities of putative hydrolases that may be involved in the metabolism of polymers containing these sugars will be discussed.



## 193 (PS II)

SALT STRESS INHIBITS ARGININE BIOSYNTHESIS IN TEPARY BEAN (*PHASEOLUS CUTIFOLIUS*)

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Two lines of tepary bean, PI 321-638 and PI 319-443, were salinized at age 7 days with Shive's nutrient solution plus 60 mM NaCl-CaCl<sub>2</sub> in a 2:1 molar ratio. Salt was added at the rate of 1/3 the final concentration every other day. The osmotic potential of the salinizing solution was -0.33 MPa. Fifteen days of salt treatment reduced plant growth 45% and inhibited the incorporation of NaH<sup>14</sup>CO<sub>3</sub> into the combined pool of arginine plus urea 60 and 85% for the two lines, respectively. The salt sensitive step in the arginine biosynthetic pathway was identified as carbamylphosphate synthetase in both lines. Incorporation of [<sup>14</sup>C]citrulline and [<sup>14</sup>C]carbamylphosphate plus ornithine were not inhibited by the salt treatment, but the incorporation of NaH<sup>14</sup>CO<sub>3</sub> remained inhibited even in the presence of added ornithine (10 mM). Inhibition at carbamylphosphate synthetase was confirmed by demonstration that the incorporation of NaH<sup>14</sup>CO<sub>3</sub> into UMP was also inhibited by salt stress. Evidence is provided suggesting that reduced availability of ornithine additionally compromised both arginine and pyrimidine biosynthesis during salt stress.

Supported by the Citrus Research Center and Agricultural Experiment Station of the University of California, Riverside.

## 194 (PS V)

MICROPROPAGATION OF WHITE EASTERN REDBUD (*CERCIS CANADENSIS* VAR. *ALBA*). S. Yusnita\*, Robert L. Geneve and Sharon T. Kester. Department of Horticulture, University of Kentucky, Lexington, KY 40546

In vitro shoot multiplication of white Eastern redbud was successful using two-node mature explants from the initial spring flush on a woody plant medium (WPM) supplemented with benzylaminopurine (BAP). Optimal shoot proliferation was obtained at 10-15 µM BAP. Treatment with thidiazuron produced fasciated (stunted) adventitious shoots which failed to elongate. Successive subcultures increased the ability of explants to form shoots. However, shoot tip necrosis became a problem after 7-8 subcultures. Shoot tip necrosis is being studied by comparing shoot multiplication on bacto-agar vs. gelrite, increasing the Ca concentration in WPM and by trying to reduce the phenolic exudate by the explants with PVP or activated charcoal. Microshoots >3 cm long were rooted by pulse treatment on half strength WPM containing 300 µM IBA or NAA before being moved to hormone free WPM. There was a different morphology between IBA and NAA induced roots, although the number of roots were comparable. IBA treated microcuttings developed branched, fine roots, whereas NAA treated plants produced unbranched, coarse roots. Rooted microshoots were successfully acclimated to greenhouse condition.

## 195 (PS VIII)

CHANGES IN THE ACTIVITIES OF PHOSPHOFRUCTOKINASE, AND PYROPHOSPHATE FRUCTOSE-6-PHOSPHATE PHOSPHOTRANSFERASE, AND IN THE LEVELS OF FRUCTOSE-2,6-DIPHOSPHATE, PYRUVATE AND ATP IN RESPONSE TO C<sub>2</sub>H<sub>4</sub> IN AIR AND 3% O<sub>2</sub>

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The mechanism of C<sub>2</sub>H<sub>4</sub> action on plant respiration is not well understood. In the present work we treated peeled sweet potato roots (*Ipomea batatas* cv. MD715) with 10 ppm C<sub>2</sub>H<sub>4</sub> in air and 3% O<sub>2</sub>. Analytical data showed a close relationship between respiration and activity of phosphofructokinase while the activity of pyrophosphate fructose-6-phosphate phosphotransferase remained constant under all experimental treatments. At the respiratory peak there was an increase in both pyruvate and fructose-2,6-diphosphate. The change in the levels of pyruvate, followed closely that of the respiration drift, while those of fructose-2,6-diphosphate did not correlated so closely. The data indicate that the stimulation of respiration by C<sub>2</sub>H<sub>4</sub> in sweet potato roots is closely associated with an enhancement of glycolysis. The levels of ATP also increased with the rise in respiration and reflected the magnitude of the respiratory increment.

## 196 (PS II)

## RELATIONSHIPS BETWEEN CROP WATER STRESS INDEXES AND PHOTOSYNTHESIS, CONDUCTANCE, OR COLD HARDINESS OF PEACHES

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Water stress in mature 'Redhaven' / Lovell peach [*Prunus persica* (L.) Batsch] trees was imposed, during the 1988 growing season. Trickle irrigation was reduced from 100% to 25% of a calculated weekly evaporation amount on 22 June, 11 July, and 8 and 27 Aug. Trees were isolated from rainfall by tents under the canopy and from horizontal water movement between root systems on 4 sides to a depth of 0.5 m by a water-proof barrier. Canopy to air temperature differentials monitored

throughout the growing season were developed into 3 stress indexes: crop water stress index (CWSI); cumulative crop water stress index (CCWSI); and postharvest cumulative crop water stress index (PCCWSI). CWSI values varied from 0 to 0.6, while both CCWSI and PCCWSI increased through late Sept. Mean PCCWSI of the 22 June 25% treatment increased at a greater rate than the other treatments. Significant linear regressions were found with some of the indexes and net photosynthesis or stomatal conductance; however, the r-square values were low. In general, no linear relationships were found between either CCWSI or PCCWSI and the Index of Injury for cold hardiness.

## 197 (PS V)

## ROLE OF SYMPATHY FLOWERS IN FUNERAL RITUALS

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An important sector of florists' business is sympathy flowers. Although flowers are still a component of the funeral, florists are seeing a decline in their sympathy sales. Do flowers serve a role in the funeral ritual? Surveys of funeral directors, grief therapists, and the recently bereaved were conducted to answer this question.

Survey results show that sympathy flowers serve two very different roles in the bereavement process - an emotional role and a functional role. In the emotional role, flowers at the funeral symbolize the care and sympathy people feel towards the survivors. The flowers provide comfort to both the sender and the receiver. Flowers also serve a more functional role, that is, the flowers are noticed in very tangible ways. During the visitation or funeral service the flowers are looked at, touched, smelled, or talked about. The flowers provide a diversion or a starting point for conversation.

A better understanding of the role of sympathy flowers in funeral rituals can help florists, funeral directors, and grief therapists better serve their customers or clients.

## 198 (PS VIII)

## EXTENSION OF MUSKMELON POST-HARVEST LIFE THROUGH THE USE OF HOT WATER TREATMENT AND POLYETHYLENE CARTON LINERS

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Trials were conducted in California to evaluate techniques to extend post-harvest life of Western shipper-type muskmelon cultivars (*Cucumis melo* L.). The use of .025 mm polyethylene bags, either as individual melon wraps or as liners for 18 kg commercial cartons, minimized water loss and associated softening of the fruit. A three minute dip in 58-60°C water effectively checked surface mold and decay. The combination of hot water dip and polyethylene carton liner maintained high quality marketable fruit for at least 30 days of cold storage at 2-4°C. This technique would require only modest changes in commercial handling practices, with minimal additional per carton cost. Commercial utilization of this technique could stimulate the export of California muskmelons to Pacific Rim countries.

## 199 (PS II)

## CHANGES IN ENZYMES AND PROTEINS IN SALT-SHOCKED VS. GRADIENT INCREASES IN NaCl IN 'POINSETT' CUCUMBER ROOTS

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*Cucumis sativus* L., 'Poinsett' seedlings were grown under artificial light in 40% modified Hoagland's solution until an average plant plastochron index of 4.73 was reached. Plants were then placed in solutions of (1) 0 mM NaCl, (2) 80 mM NaCl (salt-shock), or (3) placed in a dropwise gradient solution of NaCl and Hoagland's until the final concentration of 80 mM NaCl was reached at 41 hours. Leaves of the 80 mM shock treatment wilted immediately, but recovered turgor within 6 hours. Leaves of 80 mM gradient did not wilt at anytime. The control and gradient treatments had relative growth rates which were similar to each other, but RGR decreased in the shock treatment. Invertase activity was measured in the roots at 24, 41, and 48 hours after initial treatment. Invertase activity of shock treatment increased significantly over the controls at 24 hours. The 80mM gradient was not significantly different than either treatment. Four isozymes of α-galactosidase were detected. The relative intensities of the bands varied with time and treatment. One invertase band was resolved in roots on 8% native acrylamide gels. SDS gels indicated increases in proteins in the gradient treatment compared to the control and the 80 mM shock treatment.



## 200 (PS V)

## INFLUENCE OF PHOTOPERIOD AND GIBBERELIC ACID ON GROWTH AND FLOWERING OF CRASPEDIA UNIFLORA.

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Flowers of *Craspedia uniflora* (Billy Buttons), a New Zealand annual plant, have been introduced recently into the U.S.A. florist market. *Craspedia* is relatively unknown in the U.S.A., but is beginning to be utilized by florists as a cut flower and has potential for specialty cut flower production. *Craspedia uniflora* cut flowers were grown from seed in an inflated, double-layer, polyethylene greenhouse. Short day (SD) and long day (LD) photoperiod treatments were applied by daylength reduction via black cloth and night interruption lighting, respectively. Treatments began 10 weeks after sowing (15 leaf stage) and continued until harvest. Gibberellic acid was applied as a single foliar spray to runoff at 0 and 500 mg-liter<sup>-1</sup> at initiation of photoperiod treatment. Long day treatment reduced days to anthesis, increased flower number, and decreased stem length and plant fresh weight. Gibberellic acid (500 mg-liter<sup>-1</sup>) increased foliage height under both photo period treatments and increased plant dry weight under LD but reduced dry weight under SD treatment. Flower fresh weight, diameter and bud number were not affected by treatment.

## 201 (PS VIII)

## VARIABLES IN PROCESSING PROTOCOL THAT AFFECT THE SHELF-LIFE AND POSTHARVEST PHYSIOLOGY OF SHREDDED CABBAGE

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Antioxidants and certain variables in the processing protocol were evaluated for their influence on the respiration, ethylene production, color, and storage potential of shredded cabbage (*Brassica oleracea* L. var. capitata). Four commercially available antioxidants were compared to ascorbic acid and sodium metabisulfite. Compounds were applied either by dipping or by vacuum infusion after the cabbage was shredded. Weight changes occurring during each step of processing were measured. Shredded cabbage was packaged under vacuum in 1.75 mil polyethylene bags and stored at 4°C. In all studies, untreated controls had longer shelf life than any of the treated shredded cabbage based on subjective evaluation as well as objective color scores. Respiration and ethylene production were not influenced by treatment other than centrifugation immediately after shredding, which reduced the rate of both processes by about 50%. Any treatment resulting in weight gain, e.g. vacuum infusion or dipping in aqueous solutions, caused a decrease in shelf life.

## 202 (PS II)

## EFFECTS OF INCREASED SALINITY ON PHOTOSYNTHETIC CAPACITY OF 'MICRO TOM' MINIATURE DWARF TOMATO

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Tolerance of increased salinity by tomato is of great importance to the tomato processing industry, where increased conductivity of up to 6 dS m<sup>-1</sup> is used to increase specific yield components. A new line of miniature dwarf tomato, *Lycopersicon esculentum* Mill. cv. Micro Tom, was evaluated for photosynthetic response to elevated salinity. Tomatoes were grown in solution batch culture and subjected to constant salt treatments of 2.4 (control), 7.6, 12.8, or 18 dS m<sup>-1</sup>. Weekly photosynthetic measurements were made beginning week 4 on the most recent fully open leaf or leaf opposite a fruit. Net photosynthesis decreased across all salt treatments over the last six weeks of sampling. As salinity level increased, net photosynthesis decreased compared to the control. The 18 dS m<sup>-1</sup> treatment reduced net photosynthesis relative to 12.8 and 7.6 dS m<sup>-1</sup>. Although salinity increased succulence, limitations to net photosynthesis were due to diminished utilization of intercellular CO<sub>2</sub>, rather than reduced internal CO<sub>2</sub> concentration or stomatal conductance.

## 203 (PS V)

## CONTROLLED-RELEASE FERTILIZER REGIMES INFLUENCE PRODUCTION AND POSTPRODUCTION QUALITY OF POTTED CHRYSANTHEMUMS

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Controlled-release fertilizers (CRF), Nutricote 14N-6.2P-11.6K or Osmocote 14N-6.2P-11.6K, at the recommended rate (1x) and at half that rate (0.5x) plus 200 mg/l N of Peter's 20N-4.4P-16.6K water soluble fertilizer at every

irrigation were applied to potted chrysanthemums cv. 'Bright Golden Anne' and 'Torch'. Production and postproduction quality was evaluated. CRF applications (1x) resulted in reductions of plant height (-10%), plant diameter (-17%), leaf area (-35%), and leaf dry weight (-47%), but did not affect number of flowers compared to plants receiving only water soluble fertilizer. Application of water soluble fertilizer with CRF (0.5x) increased foliar nutrient levels above water soluble fertilizer application alone, or above either CRF (1x). CRF applications (1x) resulted in improved floral longevity (up to +8 days) and flower color rating (up to +54%), and less foliar senescence (up to -45%) than the water soluble fertilizer application alone, or either of the CRFS (0.5x) used with water soluble fertilizer.

## 204 (PS VIII)

## WORLD'S LARGEST, SMALL CHAMBER, RECIRCULATING, CONTROLLED ATMOSPHERE (CA) STORAGE RESEARCH FACILITY

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A grant from the Pa. Dept. of Agriculture has allowed Penn State University to increase postharvest physiology research of fruit, vegetables, and mushrooms. One part of this program is a CA storage research facility described herein. An insulated pole barn (26m x 18m with 5m ceilings) houses the facility. Three coolers (6m x 7m with 10cm insulation) provide environmental control for the CA systems (-2 to 10C ±0.5C). A laboratory within the building (6m x 7m x 3m) provides space for product evaluation and for CA control equipment. A total of 239 steel drums (208-liter), fitted with 28 cm round plexiglass windows, are the CA chambers. Gas pumps provide flow to: each chamber, the gas analysis system, and the CO<sub>2</sub> scrubbing system. A David Bishop Instruments Oxystat 2, analyzes O<sub>2</sub> and CO<sub>2</sub> and provides control signals. High CO<sub>2</sub> can be removed either by lime scrubbing or by flushing with gases containing N<sub>2</sub> and the desired O<sub>2</sub> level. Several large experiments involving 7.8 MT of apples were started and preliminary results will be presented.

## 205 (PS II)

## CHRONIC OZONE EXPOSURE AFFECTS FREEZE RESISTANCE IN CITRUS AND AVOCADO

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The effects of elevated levels of ozone on growth, mineral nutrition and freeze resistance were studied using broadleaf-evergreen citrus and avocado trees. 'Ruby Red' grapefruit (*Citrus paradisi* L.) trees on either Volkamer lemon (*Citrus volkameriana* Ten. & Pasq.) or sour orange (*Citrus aurantium* L.) rootstock and 'Simmonds' or 'Pancho' avocado trees (*Persea americana* Mill.) on the rootstock 'Waldin' were exposed to ozone in open-top chambers for 4 mo in 1988 and in a second experiment in 1989 for 8 mo. Citrus tree growth, estimated by total leaf mass, was unaffected by ozone concentrations of 3 times ambient in either year but avocado growth was reduced by ozone concentration at 2 times ambient in 1989. All trees were well-fertilized and ozone had little effect on mineral nutrient concentrations in leaves. Freeze resistance, estimated by electrolyte leakage from leaf disks and survival of leaves, stems, and whole-plants following exposure to freezing temperatures, was often diminished in avocado and citrus at 3 times ambient ozone, but occasionally was increased at 2 times ambient. Thus, ozone can be related to shifts in freeze resistance that can occur prior to discernible growth effects.

## 206 (PS V)

THE EFFECTS OF BA + GA<sub>4+7</sub> AND DIKEGULAC-SODIUM + GA<sub>4+7</sub> ON INITIATION AND DEVELOPMENT OF VEGETATIVE SHOOTS OF AZALEA

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Experiments were designed to determine if the combination of 6-benzyl adenine + gibberellic acid<sub>4+7</sub> can promote increased lateral shoots of desirable number and length on azaleas (*Rhododendron simsii* Planch.). The use of dikegulac-sodium with the addition of GA<sub>4+7</sub> was also investigated to determine if GA<sub>4+7</sub> could overcome decreased plant height and diameter caused by dikegulac application. Treatments were applied by spraying 204 ml-m<sup>-2</sup> to pinched plants of mean diameter and mean height of 16 and 13 cm, respectively, potted in 1.3 liter plastic containers. Shoot number, plant height and plant diameter were measured 9 weeks after application for the commercially prominent cvs. 'Gloria' and 'Prize'. Preliminary

results indicate that 2100 mg·l<sup>-1</sup> ai BA + 2100 mg·l<sup>-1</sup> ai GA<sub>4+7</sub> increases number of lateral shoots. Initial results suggest the addition of 2100 mg·l<sup>-1</sup> ai GA<sub>4+7</sub> to 3900 mg·l<sup>-1</sup> ai dikegulac overcomes inhibition of internodal elongation induced by dikegulac alone. Further studies will determine the effectiveness of Promalin (N-(phenylmethyl)-1H-purine-6-amine + GA<sub>4+7</sub>, 1:1) as a pinching agent on azaleas.

## 207 (PS VIII)

PROTEIN PATTERNS DURING GERMINATION OF *Lactuca sativa* 'Empire'. David W. Still\* and Kent J. Bradford. Department of Vegetable Crops, University of California, Davis, CA 95616

Lettuce seeds were germinated at 20 C in the dark in water and sampled at various intervals during the first 18h of germination to determine quantitative and qualitative differences in proteins. The soluble protein fraction was partitioned into albumins and globulins by dialysis and the proteins of the globulin fraction were visualized by SDS-PAGE. Heat stable proteins were obtained by boiling the proteins, cooling on ice, and resuspending in buffer.

The soluble protein content remained constant during the first 8h of germination. Thereafter protein content decreased and was 6% of the amount present in unimbibed seed in 21 day old seedlings. The ratio of heat stable to heat unstable proteins decreased during the germination process. No differences in banding patterns were observed when the soluble protein fraction were run on SDS-PAGE. However, on gels run with the globulin fraction a 57 kD protein appeared 4 and 8 h after imbibition and had disappeared by 12 h after imbibition. The role of proteins and heat-stable proteins during germination and prevention of dessication during early seedling growth is discussed.

## 202 (PS II)

THE RESPONSE OF TABLE GRAPE GROWTH AND RIPENING TO WATER STRESS

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Arizona is currently experiencing an explosion in the commercial cultivation and production of table grapes. Decreasing water supplies, increasing water cost, and recent groundwater legislation are forcing Arizona growers to be more water efficient if they are to remain competitive with other markets. Research was conducted to determine the effect of water stress on vine growth and berry ripening. "Flame Seedless" table grapes (4th leaf) were subjected to increasing water stress levels based upon infrared canopy temperatures and the crop water stress index (CWSI). A lower water stress level (CWSI = 0.18 units at irrigation) promoted earlier berry sizing, increased berry weight, and increased cluster weight over drier treatments. Significantly higher growth ( $P=0.01$ ), based on pruning weights, also was attained at the lower water stress level. However, highest production (grade 1 and 2 packed boxes) was attained when irrigations were scheduled at 0.30 CWSI units. Total applied water to maintain the wet, medium, and dry treatments was 1136 mm (CWSI = 0.18), 775 mm (CWSI = 0.30), and 669 mm (CWSI = 0.33), respectively.

## 209 (PS V)

A NEW METHOD FOR MEASURING TOTAL POROSITY IN HORTICULTURAL SUBSTRATES

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The determination of air and water holding capacities of horticultural substrates has been plagued by errors in measurement. The amount of air and water held at container capacity is influenced by the substrate and container height. Container capacity can be established through specific measurement. Air space, the difference between total porosity and container capacity, is usually poorly determined because of errors in total porosity measurement. Most researchers calculate total porosity ( $S_t$ ) from the formula:  $S_t = 1 - (\rho_b/\rho_p)$ , where  $\rho_b$  is the dry bulk density and  $\rho_p$  is the particle density. While bulk density is usually measured, particle density is not. Many times an average  $\rho_p$  of 2.65 Mg·m<sup>-3</sup> for mineral soils is used. This sometimes creates large errors in calculating total porosity because the values of  $\rho_p$  for horticultural substrates range from 0.35 to 2.1 Mg·m<sup>-3</sup>. Total porosity can be measured with great accuracy at 0 kPa tension on a pressure plate apparatus, but is costly in equipment and time. Using a modified method of extraction and a new apparatus, using standard aluminum soil sampling cylinders, total porosity was measured with an 85% reduction in time and no decrease in accuracy.

## 210 (PS VIII)

INTERNAL BROWNING IN 'ATLANTIC' POTATO TUBERS AS AFFECTED BY CALCIUM, IRRIGATION, AND STRAW-MULCHING

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Internal brown spot (IBS) was found consistently in the 'Atlantic' cultivar at Lexington in 1967, 1968 and 1989, and at Owensboro and Quicksand, KY in 1987. Treatments of foliar and soil applied CaSO<sub>4</sub> in 1987, soil-applied CaSO<sub>4</sub> in 1988, and straw mulching in 1989 did not reduce IBS. Irrigation increased IBS because of larger tubers and increased Ca content of plants as compared with non-irrigated plants. Tubers showing IBS had higher Ca content in affected tissue than in non-affected tissue. Both IBS and Ca content of leaves increased as the plants aged.

## 211 (PS II)

ABSCISIC ACID AND WATER RELATIONS MODELS OF SEED GERMINATION. Bing-Rui Ni\* and Kent J. Bradford. Department of Vegetable Crops, University of California, Davis, CA 95616

Cell growth models were applied to characterize the response of seed germination, based upon the timing of radicle emergence, to  $\gamma$  and ABA. Using probit analysis, three basic parameters can be derived to describe the population characteristics of seed lots. In the response of seed germination to osmotic stress, these three parameters are the "hydrotic constant" ( $q_{\gamma}$ ), the mean base water potential ( $\gamma_b$ ), and the standard deviation ( $S_{\gamma_b}$ ) of the seed population. In the response to ABA, they are the "ABA-time constant" ( $q_{ABA}$ ), the mean base ABA concentration ( $ABA_b$ ), and the standard deviation ( $S_{ABA_b}$ ) of the seed population. Using only these three parameters, germination time courses can be predicted at any corresponding medium  $\gamma$  or ABA concentration. In the presence of both ABA and osmotic stress, the same parameters can be used to predict seed germination time courses with any combination of  $\gamma$  and ABA concentration. The water relations model and the ABA model were additive and it appeared that the two factors slowed down germination independently. Effects of osmotic stress and ABA on the parameters in Lockhart equation are also discussed.

## 212 (PS V)

ROSE LEAF SURFACE - BLACKSPOT DISEASE RESISTANCE: A SCANNING ELECTRON MICROSCOPE VIEW

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Blackspot disease, caused by *Diplocarpon rosae*, is a devastating disease of garden roses. Most hybrid teas and floribundas are susceptible to this disease in contrast to many species roses, which are resistant. The basis of this resistance is not known. The first barrier to invasion by the pathogen is the outer surface of the leaf. The physical nature of this surface may influence the attempted infection, landing, germination and penetration by the fungal spore and may cause a failure of infection. The leaf surfaces of susceptible and resistant genotypes were observed using SEM that allowed examination of the fine structure of the leaf surface. The characteristics of the leaf surface topography including wax structures were pictorially compared and visual concepts developed in relation to the dynamic nature of the leaf surface in space and time as leaf is infected by the pathogen.

## 213 (PS VIII)

STAYMAN FRUIT CRACKING AS RELATED TO CW COMPOSITION

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Stayman apples are predisposed to cracking. Trees whose trunks were scored and foliage sprayed with GA<sub>4+7</sub>, NAA 800, and Vapor Guard had significantly fewer apples crack than controls. The skin strength and stretch distance were the same for control and treated apples. However, slices of treated apple expanded significantly more than control apples when immersed in distilled water for 45 minutes. During this treatment the amount of water taken up was not significantly different, which may indicate the difference lies in the cell structure. Hypodermal cells of control apples appear to be more elongated and have thicker cell walls than treated apples. Cell wall sugar and amino acid components will be measured to see if this discrepancy can be attributed to cell wall structural properties. These

results suggest that stayman cracking occurs when the expansion of the hypodermic cannot keep pace with expansion of the fruit. It is further hypothesized that this difference is due to a difference in cell wall composition and consequent effect on wall extensibility.

## 214 (PS II)

### WATER REQUIREMENTS OF GROUND COVER SPECIES IN CENTRAL ARIZONA

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Determination of water needed for good function of established groundcovers in the Southwest is important in creating well-adapted, sustainable urban landscapes in this semi-arid region. *Myoporum parvifolium* from Australia and *Dalea greggi* from the Chihuahuan Desert were tested at 100%, 75%, 50% and 25% of evaporation from an adjacent class A pan. *Myoporum* grew most at the higher irrigation regimes, but actually performed best at the lowest irrigation level, growing less than those given more water, but showing better color and vigor. Infrared leaf temperature data showed that lowest irrigation regime plants still transpired actively and had cool leaves. With *Dalea*, growth was directly related to water applied, with the most growth at the 100% treatment. All plants survived, but the lowest irrigation regime plants were sparse and showed definite signs of water stress. Infrared temperature measurements indicated increasing water stress as water applied decreased. At treatment onset, the *Dalea* had not completely covered the soil surface, so 75% of pan evaporation can be considered adequate for establishment of *Dalea*.

## 215 (PS V)

### ASEXUAL PROPAGATION OF SHEPHERDIA CANADENSIS AND SHEPHERDIA ROTUNDIFOLIA

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In recent years there has become an increased demand for native, drought-tolerant species for private landscaping and revegetation of disturbed sites; especially in the Rocky Mountains and high plains states. *Shepherdia canadensis* and *S. rotundifolia*, native to much of this area, have already increased in popularity due to their drought tolerance and general hardiness. Micropropagation and rooting of cuttings have been investigated for these two species. *S. canadensis* hardwood stem cuttings were successfully rooted with 0.8% IBA at 46.5% as compared to less than 5% from previous research. *S. rotundifolia* produced a greater number of axillary shoots on WPM as compared to MS medium and at a moderate concentration of BA.

## 216 (PS VIII)

### SHORT TERM STORAGE OF PLUG-GROWN BEDDING PLANT SEEDLINGS.

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The effects of differing storage conditions prior to transplanting were examined for *Salvia splendens* 'Red Hot Sally', *Impatiens wallerana* 'Super Elfin White', *Viola*  $\times$  *wittrockiana* 'Universal Beaconsfield' and *Petunia*  $\times$  *hybrida* 'Supercascade Lilac'. Plug-grown seedlings were stored for 0, 1, 2 or 3 weeks at 5C or 10C and irradiance levels from incandescent bulbs at 0, 2 or 12  $\mu\text{mol s}^{-1}\text{m}^{-2}$ . A second group of plants were stored at 18C and irradiance from fluorescent bulbs at 105  $\mu\text{mol s}^{-1}\text{m}^{-2}$  for the same time period. Temperature was more important than irradiance in maintaining plant quality over the storage period. *Impatiens* and *salvia* could be stored successfully for a minimum of 2 weeks at 5 or 10C with no appreciable loss of quality, *petunia* and *pansy* up to 3 weeks. Seedlings of all species showed diminished quality when stored longer than 1 week at 18C. After storage, *petunias* stored at 18C flowered sooner than those stored at 5 or 10C. However, these plants were single stemmed, with long internodes and few flowers while those plants stored at 5 or 10C developed multiple branching and a short, compact growth habit at flowering.

## 217 (PS II)

### EFFECT OF HYDROPHILIC POLYMER AND IRRIGATION REGIME ON GROWTH AND CUTTING PRODUCTION OF GOLDEN TORCH CACTI

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Golden Torch Cactus (*Trichocereus spachianus*) from Argentina is a handsome, cold-hardy, columnar cactus with excellent landscape potential. Hydrophilic polymer in combination with 5 watering regimes has been tested to determine the optimal water cost-effective manner to produce these cacti. The hydrophilic polymer is a highly absorbent polyacrylamide compound. The summer water regimes tested were: rainfall only, irrigation twice per week, once per week, twice per month, and monthly. The study was evaluated at 16 and 36 months. Amendment with polyacrylamide resulted in significant depression in total cuttings and total length of cuttings as of 16 months, but this effect had disappeared as of 36 months. There were no significant interactions between the polyacrylamide and irrigation regime variables. Irrigation regime significantly affected performance throughout the course of the study. Weekly irrigation (summer) resulted in the greatest cost benefits in terms of production as a function of water applied. Cultivation under ambient rainfall resulted in 100% survival and modest production, as compared with irrigated plants.

## 218 (PS V)

### ASEXUAL PROPAGATION OF CEANOTHUS VELUTINUS AND CEANOTHUS FENDLERI

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The evergreen *Ceanothus velutinus* and semi-evergreen *C. fendleri* are native Colorado, drought-tolerant shrubs. They are of interest for landscaping and rock gardens, but have poor seed germination as well as vary considerably in growth form and habit. Asexual propagation methods would be important for commercial development of these species. Basal hardwood cuttings of *C. velutinus* were rooted using four different concentrations of IBA. The highest concentration of IBA (0.8%) showed the highest rooting (14.8%), while the average number of roots per cutting was highest for 0.1%. *Ceanothus fendleri* shoot tips were cultured on MS medium with four BA (0.89, 4.4, 8.9 and 17.8  $\mu\text{M}$ ) and three 2ip concentrations (24.6, 49.0 and 73.6  $\mu\text{M}$ ). After nine weeks an average of six shoots were produced in treatments having 4.9  $\mu\text{M}$  of BA. Lower concentrations of BA up to 9.8  $\mu\text{M}$  were better than higher concentrations of BA or 2ip. There was a tendency for production of callus at the higher levels of BA and all levels of 2ip.

## 219 (PS VIII)

### SQUALENE APPLIED TO GRAPEFRUIT PREVENTS CHILLING INJURY

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In previous studies squalene was shown to be synthesized in grapefruit under temperature-conditioning parameters optimal for preventing chilling injury (CI). In this study, squalene and its saturated derivative squalane were applied to the fruit as sprays or dips under various protocols. Fruit were stored for various times under conditions conducive to CI. The best results were obtained when fruit were sprayed with squalene dissolved in hexane. After 4 weeks at 5C, 5% squalene reduced CI 69% and 10% squalene reduced CI 80% whereas, temperature conditioning reduced CI by a comparable amount (67%).

## 220 (PS II)

### RELATIONSHIPS BETWEEN GRAVIMETRIC WATER LOSS MEASUREMENTS AND PLANT WATER STRESS RESPONSES

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Previous work has shown that container grown landscape plants use, and likely need, much less water than is typically applied. Therefore, studies were conducted to quantify the relationships between water loss and water stress responses using several drought tolerant (*Cassia corymbosa*, *Leucophyllum frutescens*, *Salvia greggii*) and traditional landscape plants (*Euonymus japonicus*, *Pyracantha*

coccinea). Water stress was induced by withholding water and water loss measured gravimetrically. The shape of the water loss curve was similar for all species being,  $Y = a + bx + cx^2$  ( $r^2 > 0.95$ ). The rate of ethylene production began to increase 24 hr after irrigation, reaching a maximum 36-48 hr after irrigation and then decreasing. Maximum ethylene production occurred at 35-47% water loss irrespective of species or rate of water loss. Stress symptoms (wilting leaf discoloration and abscission) followed a similar pattern. The potential for monitoring gravimetric water loss to schedule container irrigation will be discussed.

## 221 (PS V)

### MICROPROPAGATION OF ACER GINNALA.

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Shoot proliferation of *Acer ginnala* Maxim. (Amur maple) from nodal-segments was obtained on Murashige and Skoog salts and vitamins supplemented with 25 nM thidiazuron and 3% sucrose. Higher concentrations of cytokinin resulted in callus formation at the base of explants. Explant orientation had a significant effect on shoot elongation. Explant elongation and proliferation were correlated. Plants inverted in the medium elongated and proliferated readily. Branching was obtained primarily from axillary buds several nodes basal to the apex. Gelling agent type did not affect proliferation. Vitrification was significantly affected by type of gelling agent, gelling agent concentration and thidiazuron concentration. In vitro shoots rooted readily even in medium containing adenine. Greater than 95% of the in vitro plants established in the greenhouse.

## 222 (PS VIII)

### VARIABLE ATMOSPHERIC PRESSURES ACCELERATE POST-HARVEST GAS TRANSFER IN BULKY PLANT MATERIALS

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Effective gas flow between plant materials and their surrounding atmosphere is necessary to enable controlled atmospheres to act on stored produce and maintain produce quality. Gas flow can be motivated in two ways: by component gas concentration (i.e. partial pressure) gradients and by total as pressure gradients. Varying the total gas pressure about stored plant material should cause gas flow which supplements that induced by concentration gradients alone. Novel measurement techniques were developed to explore the effects of varying atmospheric pressure and gas composition on gas transfer rates. In apple fruit, gas transfer rate undergoes a several-fold increase with small pressure fluctuations. There is a direct increase in gas transfer rate as the amplitude of pressure variation increases, and optimum periods of oscillation fall in the range of 20 to 60 seconds. Apples, onions, and other commodities with large internal gas volume and intermediate peripheral resistance to bulk gas flow, seem to be most responsive to total pressure variation.

## 223 (PS II)

### WATER REQUIREMENTS OF WOODY LANDSCAPE SHRUBS

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Four woody plant species were grown during the 1988 and 1989 growing seasons under three irrigation treatments at two sites in two soil types. The three irrigation treatments which were implemented included: 1) control, 2) drip irrigated with no water stress, and 3) drip irrigated with water stress. Rainfall and additional water applied during the 1988 and '89 growing seasons were recorded. Analysis of this data showed the no stress treatment receiving more water at both sites, especially in 1989. After two years of growth, no statistical differences in new growth (height) were observed with any plant species evaluated at either site from the three water treatments. Comparing new growth, no statistical differences were observed except with *Juniperus sabina*. No visual differences were observed with *Ribes alpinum* and *Cornus sericea*. Visual

differences were observed with *Potentilla fruticosa* and *Juniperus sabina*. The experiment will be continued during the 1990 growing season.

## 224 (PS V)

### STOCKPLANT ETIOLATION AND SHOOT AGE EFFECTS ON ANATOMY AND ADVENTITIOUS ROOT FORMATION IN STEM CUTTINGS OF CARPINUS BETULUS 'FASTIGIATA'

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New shoot growth of *Carpinus betulus* 'fastigiata' was treated with stockplant etiolation and stem banding treatments and sampled for anatomical study at intervals over a 16-week period of greening following etiolation. Shading effects on the anatomy of the stem were also investigated. Numerous anatomical changes were noted with stem age and stockplant treatment. Among these were etiolation effects on the lignification of the secondary xylem, thickness of the periderm, and an increase in the percentage of sclereid-free gaps in the perivascular sclerenchyma. Stem banding increased the widths of the cortex and pith. Concomitant propagation studies revealed significant etiolation, shading, and banding effects on rooting percentages and root numbers. Using multiple linear regression methods rooting capacity was modelled best by linear combinations of the widths of the pith, non-lignified secondary xylem, cortical parenchyma and periderm, as well as the percentage of gaps in the sclerenchymatic sheath remaining non-sclerified. It is proposed that the development of sclereids in potential rooting sites reduces rooting potential. The exclusion of light during initial shoot development retards sclereid development by up to 3 months following treatment, which correlates well with observed increases in the rooting potential of etiolated and/or banded stems.

## 225 (PS VIII)

### PREGERMINATION TREATMENTS AND TEMPERATURE REQUIREMENTS FOR GERMINATION OF MEXICAN REDBUD, EVERGREEN SUMAC, AND MEALY SAGE SEEDS.

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The maximum predicted germination was 95% after 62 minutes scarification and 35 days stratification for mexican redbud (*Cercis canadensis* var. *mexicana*) and 59% after 52 minutes scarification and 73 days stratification for evergreen sumac (*Rhus virens*). Mexican redbud germination occurred from 24 to 31 C, evergreen sumac from 21 to 31 C, and mealy sage (*Salvia farinacea*) from 21 to 34 C. The maximum predicted final percent germination and the temperature at which it occurred for mexican redbud, evergreen sumac, and mealy sage was 104 at 27 C, 90 at 29 C, and 42 at 22 C, respectively. The maximum predicted maximum germination rate and the temperature at which it occurred for mexican redbud, evergreen sumac, and mealy sage was 30 at 31 C, 69 at 31 C, and 104 at 27 C, respectively. The minimum predicted inflection time and the temperature at which it occurred for mexican redbud, evergreen sumac, and mealy sage was 4 days at 28 C, 10 days at 25 C, and 3 days at 28 C, respectively.

## 226 (PS II)

### A NEW MODEL TO SIMULATE DIURNAL TEMPERATURE FLUCTUATIONS FROM RECORDED MAXIMA AND MINIMA

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The following model simulates hourly temperature fluctuations at 6 Kansas stations:

$$T_h = \frac{(T_x - T_n)}{2} \left[ \exp\left(\frac{0.693h}{DL_M}\right) - 1 \right] + T_n; \quad 0 \leq h \leq DL_M$$

$$T_h = \frac{(T_x - T_n)}{2} \left[ 1 + \sin\left(\frac{\pi(h - DL_M)}{2(23 - DL_M)}\right) \right] + T_n; \quad DL_M \leq h \leq 23$$

where h = time (hours after sunrise),  $DL_M = 20.6 - 0.6 * \text{daylength (DL)}$ ,  $T_x$  = temperature at time h, and  $T_n$  = maximum and minimum temperature, respectively. Required inputs are daily  $T_x$  and  $T_n$  and site latitude (for the calculation of DL). Whereas other models have been derived by fitting equations to chronological temperatures, this model was derived by daily fitting of hourly temperatures sorted by amplitude. Errors from this model are generally lower, and less seasonally biased, than those from other models tested.

MICROPROPAGATION OF *ARONIA ARBUTIFOLIA* AND *A. MELANOCARPA*

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Increasing interest in landscape use of *Aronia arbutifolia* and *A. melanocarpa* has led to the establishment of breeding programs and selection of improved phenotypes within the genus. A micropropagation system was developed to facilitate rapid and easy multiplication of improved forms of *Aronia*. Actively growing shoot tips of *A. arbutifolia* 'Brilliantissima' and *A. melanocarpa* were used to initiate shoot proliferation from axillary buds. Optimum proliferation of shoots useful for micropropagation occurred on media supplemented with 0.5 to 1.0 mg l<sup>-1</sup> benzyladenine. Both Murashige and Skoog medium and Woody Plant medium supported vigorous shoot proliferation, but differences in culture morphology were evident. *In vitro* rooting and non-sterile rooting methods both resulted in high rooting percentages, the formation of numerous roots and subsequent rapid growth of plantlets.

## 228 (PS VIII)

## POLYAMINES REDUCE CHILLING INJURY IN MCINTOSH APPLES AND ZUCCHINI SQUASH

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Postharvest applications of polyamines reduced chilling injury of McIntosh apples and zucchini squash. McIntosh apples developed brown core, a symptom of chilling injury, after 5 months of storage at 0°C. However, this disorder was absent in fruit infiltrated with putrescine, spermidine, or spermine. Polyamine treatments also reduced softening of fruit tissue. Pressure infiltration of zucchini squash with spermine immediately after harvest reduced the severity of surface pitting during subsequent storage at 2.5°C. The elevation of spermidine and spermine levels and the augmentation of S-denosyl-methionine decarboxylase activity in squash by temperature preconditioning was also correlated with increased resistance of the squash to chilling injury.

## 229 (PS VIII)

## INVOLVEMENT OF ABSCISIC ACID IN REDUCING CHILLING INJURY OF ZUCCHINI SQUASH

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The endogenous levels of abscisic acid (ABA) in zucchini squash were increased by temperature conditioning at 10°C for 2 days. This temperature conditioning treatment reduced the severity of chilling injury in the squash during subsequent storage at 2.5°C. The ABA levels remained higher in treated squash than in untreated samples throughout storage. Direct treatments of squash with ABA at 0.5 mM and 1 mM before storage at 2.5°C increased ABA levels in the tissue and were also effective in reducing chilling injury. The involvement of ABA in reducing chilling injury will be discussed.

## 230 (PS II)

## AN APPARENT INCREASE IN SYMPASTIC WATER CONTRIBUTES TO GREATER TURGOR IN MYCORRHIZAL ROOTS OF DROUGHTED ROSA PLANTS

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Using psychrometric pressure-volume analysis, root water relations following drought were characterized in *Rosa hybrida* L. plants colonized by the vesicular-arbuscular mycorrhizal fungus *Glomus intraradices* Schenck & Smith. Measurements were also made on uncolonized plants of similar size and adequate phosphorus nutrition. Under well-watered conditions mycorrhizal colonization resulted in lower solute concentrations in root symplast, and hence lower root turgors. Following drought, however, mycorrhizal roots maintained greater turgor across a range of tissue hydration. This effect was apparently not due to increased osmotic adjustment (full turgor osmotic potentials were similar in mycorrhizal and nonmycorrhizal roots after drought) or to altered elasticity but to an increased partitioning of water into the symplast. Symplast osmolality at full turgor was equivalent in mycorrhizal and nonmycorrhizal roots but because of higher symplastic water percentages

mycorrhizal roots had greater absolute numbers of osmotic (symplastic) solutes. Drought-induced osmotic potential changes were observed only in mycorrhizal roots, where a 0.4 megapascal decrease (relative to well-watered controls) brought full turgor osmotic potential of mycorrhizae to the same level as nonmycorrhizal roots under either moisture treatment.

## 231 (PS II)

## PVCURVE: A COMPUTER SPREADSHEET TEMPLATE FOR EVALUATING PRESSURE-VOLUME CURVES

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The determination of tissue water potential components is important for understanding plant growth and response to the environment. Pressure-volume (PV) analysis is often considered to give the most accurate estimate of symplastic osmotic potential. Additional information about tissue water relations can also be computed from PV curves estimates of bulk cell wall elasticity, symplastic water volume, and turgor potential at various states of tissue water content. The generation of PV curves is a time-consuming procedure, however, and involves considerable computation. This presentation describes a computer spreadsheet template for traditional evaluation of a PV curve through linear regression of the zero turgor segment. The template allows real-time plotting of the inverse  $\psi$ /water loss relating, provides estimates of most commonly calculated PV characteristics and permits instant graphic visualizations of changes in water potential components and elasticity with changes in water potential, total tissue water and symplastic water content. The advantages of spreadsheet analysis of PV curves are simplicity, consistency, thoroughness and speed. A fleeting acquaintance with spreadsheet software and a thorough understanding of pressure-volume theory on the part of the user is assumed.

## 232 (PS V)

COMMERCIAL MICROPROPAGATION OF *Syringa* SPECIES AND HYBRIDS

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Briggs Nursery has micropropagated lilacs commercially since 1982. Presently we are producing more than 30 species and hybrids and have observed that media requirements vary significantly. In this study 5 lilacs representing a range of germtypic and phenotypic differences were examined to optimize cytokinin concentrations for shoot growth *in vitro*. Lilacs were grown on MS salts with BA, 2iP, and zeatin used individually and in combination. Plants were subculture 3 times, at 6 week intervals, at the conclusion of which quantitative data was taken with respect to shoot multiplication, elongation, and quality. These factors help determine the commercial practicality of producing lilacs through tissue culture.

## 233 (PS VIII)

## THE TOLERANCE OF MANGO TO INSECTICIDAL OXYGEN ATMOSPHERE

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Mango fruits (cv Keitt) were exposed to a continuous flow of low O<sub>2</sub> atmosphere of 0.1 to 0.2% (balance is N<sub>2</sub>) for 0 to 5 days at 20°C. Fruits were evaluated every day after exposure to low O<sub>2</sub> atmosphere, and again after 5 days in air at 20°C. A sensory evaluation test was conducted after 15 days from the initiation of the experiment. The low O<sub>2</sub> atmosphere reduced the activity of the enzymes malic dehydrogenase and isocitric dehydrogenase but did not affect the activity of  $\alpha$ -Ketoglutarate dehydrogenase. However, there was no indication of any fruit injury nor any detrimental organoleptic changes due to the low O<sub>2</sub> atmosphere. These results suggest the possibility of the application of very low O<sub>2</sub> atmosphere for postharvest insect control in mango.

## 234 (PS VIII)

RESPONSES OF "KEITT" MANGO TO SHORT TERM INSECTICIDAL O<sub>2</sub> AND CO<sub>2</sub> ATMOSPHERES

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The tolerance of "Keitt" mango to a modified atmosphere (MA) of < 0.5% O<sub>2</sub> + 70-80% CO<sub>2</sub> for 0 to 4 days and a controlled atmosphere (CA) of 2% O<sub>2</sub> + 50% CO<sub>2</sub> for 0 to 5 days was evaluated. MA and CA delayed the respiratory climacteric of the fruit. There was no significant fruit injury due to the low O<sub>2</sub> or high CO<sub>2</sub> atmosphere. Sensory evaluation tests did not indicate the presence of any off-flavors. Both CA and MA increased the activity of the enzyme ATP: Phosphofructokinase, did not effect the activity of pyruvate kinase, and MA reduced the activity of PPi: phosphofructokinase. MA reduced the levels of fructose 6-

phosphate, while phosphoenolpyruvate and pyruvic acid were not effected by both atmosphere treatments. Although insecticidal O<sub>2</sub> and CO<sub>2</sub> atmosphere resulted in changes in the glycolytic activity, there was no indication of any injury and fruits were ripened normally. This work indicates the potential of the application of M/CA for postharvest insect control in mango.

### 235 (PS VII)

#### EFFECT OF GREENHOUSE SHADING ON 'DOUGLAS' AND 'MOTO' STRAWBERRY YIELD DISTRIBUTION IN A SUBTROPICAL CLIMATE

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Strawberry (*Fragaria ananassa* Duch.) fruiting period lasts several months around the Mediterranean coast. Greenhouses in these locations will enhance earliness, however, from mid spring and on, the greenhouse inside becomes very hot, thus fruiting will be retarded; plants start forming runners, and fruiting stops earlier than in field-grown strawberry. Shading with white cloth for 1 hr (1h) or 2 hr (2h) at sunrise and sunset and unshaded treatments (0h) were studied as they would affect yield distribution and duration of 'Douglas' and 'Moto' cv. grown on mulched beds inside a polyethylene covered greenhouse. Douglas shading delayed first fruit harvest by 1 or 2 weeks under 1h or 2h, respectively in comparison to 0h. Harvest season ended in late May for all treatments, about 15 weeks long. Total yield was highest under 1h (11 tons/ha) followed by 2h (10.6 t/ha) and 0h (10.1 t/ha). Moto shading delayed first fruit harvest by 1 or 2 weeks in 1h and 2h, respectively in comparison to 0h. Harvest season ended in early June, about 18 weeks long. Total yield was comparable between 1h and 0h (31.8 t/ha), and the 2h yielded least (31.1 t/ha). In conclusion, shading may enhance slightly late production, but the economic returns are higher for an early season crop, thus shading should not be practiced.

### 236 (PS V)

#### TIMED FERTILIZER APPLICATIONS EFFECT DWARF YAUPON HOLLY GROWTH AND FERTILIZER UTILIZATION

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Multiple branched liners of *Ilex vomitoria* were greenhouse-grown in 3-liter containers with a common nursery medium and received either 2.5 g N surface-applied in 1 application as Osmocote (18N-2.6P-10K) or a total of 0, 0.5, 1.5 or 2.5 g N per container from a solution that contained N, P and K in a ratio of 6:1:3. The solution fertilizer was applied either 1, 2, 3 or 4 times per week with total N applied per container equally divided among individual applications. After 26 weeks, shoot dry weights were greatest for plants that received 2.5 g of N as either 2 soluble applications per week or as Osmocote applied once at the beginning of the experiment. Plants that received 1.5 g of N applied 4 times per week had similar shoot dry weights. Nitrogen uptake will be calculated to determine if 4 applications per week resulted in greater utilization than 2 applications per week or 1 application of Osmocote during the growing season.

### 237 (PS IX)

#### EFFECT OF HARDWOOD BARK MULCH ON THE WINTER SURVIVAL OF EIGHT CULTIVARS OF GARDEN CHRYSANTHEMUMS

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A field study was conducted at Tennessee State University's research station to evaluate the effect of hardwood bark mulch on the winter survival of garden mums. A randomized complete block design was used. Cultivars used were adorn, encore, grandchild, jackpot, legend, minnautumn, minnwhite and triumph. At the end of the flowering season the tops were removed leaving a four inch stubble in the mulch. The number of mum plants that resumed growth the following spring were counted for each cultivar. There was a difference in the winter survival of the different cultivars as well as a significant difference in the mulch treated and the control. Grandchild and jackpot were most cold hardy followed by encore, minnwhite, minnautumn, triumph, legend, and adorn. Grandchild and jackpot with four inches of hardwood bark mulch had an 88 percent survival while the control had a 44 percent survival. Adorn had a 51 percent survival with four inches of mulch and a 20 percent survival in the control. This data shows that hardwood bark mulch holds a great potential for providing excellent winter protection for garden mums.

### 238 (PS VII)

#### USE OF FIELD-LOCATED DRAINAGE LYSIMETERS FOR THE DETERMINATION OF STRAWBERRY WATER REQUIREMENTS

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Sixteen field-located drainage lysimeters (each 60 cm wide, 2.44 m long, 60 cm deep) designed specifically for determination of water requirements for fruiting strawberry production (season - Oct to April) were installed in 1986. Each lysimeter

was equipped with individual micro-irrigation and drainage collection systems automated for minimal management input. Initially, computer control (using a low-cost microcomputer) was used to continuously check switching-tensiometers located in each lysimeter and apply irrigation water as needed. A drainage suction (-10 MPa) was applied continuously to simulate field drainage conditions. Manually-installed lysimeter covers were used to protect the plots from interference from rainfall when needed. Initial irrigation application treatments were set at four levels of soil moisture tension controlled by tensiometers and were measured using flow meters for each lysimeter. This paper will discuss problems that were experienced with the initial setup (difficulty in measuring actual application amounts, tensiometer and computer control, elimination of rainfall interference, uniformity of irrigation application, and salinity in the rooting zone) and the modifications (pressurized reservoir tanks, construction of motorized rain-out shelter, micro-irrigation emitters used, and fertilization program) which have been made to overcome them.

### 239 (PS V)

#### IDENTIFICATION OF BACTERIA INFECTING MUNG BEAN SEEDLINGS USED IN ROOTING BIOASSAYS

Robert R. Tripepi\* and Mary W. George, Plant Science Division, University of Idaho, Moscow, Id 83843-4196

Mung bean (*Vigna radiata* (L.) R. Wilcz.) cuttings are used in rooting bioassays, and nonexperimental variability must be rigorously controlled to obtain meaningful results. This study was conducted to document bacterial disease problems of mung bean and identify the causal organisms. 'Berken' seeds were surfaced sterilized and aerated 24 hr before sowing. Nine-day-old seedlings were used in rooting bioassays. Up to 10% of the seedlings and 17% of the cuttings had collapsed stems or wilted leaves. A white and two yellow (Y1 and Y2) bacteria were isolated from diseased cuttings and used in subsequent pathogenicity tests. The Y2 isolate was nonpathogenic. Stems of healthy mung beans inoculated with the white isolate turned brown and collapsed 2 days after inoculation, whereas leaves of plants inoculated with the yellow isolate wilted after 7 days. Standard biochemical and physiological tests revealed that the white isolate was *Pseudomonas syringae* pv. *syringae* van Hall and the yellow isolate was *Curtobacterium flaccumfaciens* subsp. *flaccumfaciens* (Hedges) Collins and Jones. This research is the first report of a disease in mung bean caused by *P.s.* pv. *syringae*. These results demonstrate the need for disease-free seeds being used in bioassays since both pathogens were seed-borne.

### 240 (PS IX)

#### COMPARISON OF CHEMICAL AND MECHANICAL WEED CONTROL STRATEGIES FOR COWPEA

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The herbicides trifluralin, metolachlor, and paraquat were compared for efficacy of weed control in cowpea with and without cultivation as a supplemental strategy for two years. Herbicides also were compared against a no-herbicide control (with and without cultivation). Cultivation had no significant effect on seed yield, biological yield, or harvest index of cowpea. Paraquat, used in a "stale seedbed" system, was ineffective for weed control and did not change cowpea yield from that of the no-herbicide control. Trifluralin and metolachlor more than tripled cowpea seed yield compared to that of the no-herbicide control in 1988, when potential weed pressure was 886 g m<sup>-2</sup> (dry wt.). Trifluralin and metolachlor did not significantly increase cowpea seed yield compared to that of the no-herbicide control in 1989, when potential weed pressure was 319 g m<sup>-2</sup> (dry wt.). However, in 1989, these two herbicides each still increased net farm income by \$206 per hectare compared to the income obtained without an herbicide.

### 241 (PS VII)

#### EFFECT OF TIMING OF GA APPLICATION ON FLOWERING OF MACADAMIA

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Flowering of *Macadamia integrifolia* trees was monitored following application of 220 mg/liter gibberellic acid (GA<sub>3</sub>) at various times preceding the onset of the flowering season. In untreated trees, flowering extended over a 4-5 month period. When GA<sub>3</sub> was applied at 2, 3 and 4 months before the onset of anthesis, raceme production during the entire flowering season was inhibited. A slight reduction in raceme production was observed when GA<sub>3</sub> was applied at 1 month preceding anthesis. This application coincided with appearance of the earliest inflorescences. GA<sub>3</sub> application after the onset of anthesis did not alter the flowering pattern of trees during the remaining 4 months of the flowering season. Results suggest that GA<sub>3</sub> inhibits flower initiation, but has no effect on raceme emergence after flower bud differentiation has occurred. The relationship between flower initiation and raceme emergence will be discussed.

## SHOOT REGENERATION FROM LEAF DISCS OF EUROPEAN BIRCH

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A plant regeneration system that is compatible with recombinant DNA techniques is required before birch can be genetically transformed. The goal of this research is to develop a shoot regeneration system from leaf discs of European birch (*Betula pendula* Roth), since this tissue culture procedure is compatible with current transformation technology. Leaves from microplants were excised from stems, cut into approximately 25 mm<sup>2</sup> pieces, and placed on WPM media containing differing ratios of NAA (0, 3, 6, 9 µM) to BA (0, 7.5, 15, 22.5 µM) in a 4 × 4 factorial design. Four replicates, each containing 4 leaf pieces, were used per treatment. After 4 and 8 weeks, data was taken including the percent leaves forming shoots and the number of shoots per leaf disc. Only a concentration of 15 or 22.5 µM BA without NAA stimulated shoot formation on leaf discs. Data on the effects of light, media formulations and tissue orientation will be presented. With a reliable and efficient shoot regeneration system for European birch, genetic engineering of this species is now possible.

## 243 (PS IX)

## CRANBERRY BOG SOIL pH: HISTORIC AND CURRENT RELATIONSHIP TO YIELD.

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An extensive study (276 samples) was conducted in 1960 to correlate cranberry (*Vaccinium macrocarpon*, Ait.) bog soil pH and productivity (Chandler, F. B. and Demoranville, I. E. 1961. *Cranberries* 26(3):9-10). At that time, soil pH averaged 4.37 and excellent productivity was represented by a yield greater than 10 mT/ha. Thirty years later, when more than 28 mT/ha is considered good yield, soil samples will be collected from these same sites and evaluated for pH by the methods used previously. Production records for the past three years will be obtained and the average value for each location used to construct a regression of bog yield vs soil pH. Information presented will include: 1. productivity vs soil pH in 1960 and 1990; 2. change in soil pH after 30 years?; 3. possible reasons for changes-if any (grower interviews); 4. implications for the future.

## 244 (PS VII)

## COPPER DEFICIENCY IN CALIFORNIA WALNUT

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Initial leaf tissue-analysis indicated that the degree of distortion and dieback in a young walnut orchard was correlated with decreasing amounts of Cu in the leaf. Complete correction of Cu deficiency was obtained for two years when high rates of Kocide 101 were used or when low rates were applied repeatedly each year. Soil treatments gave partial correction; soil injected treatments showed continued improvement over time. Tissue analysis for Cu correlated well with the degree of distortion and dieback in the trees. Critical Cu levels in the walnut kernel were 4 ppm and 3 ppm in the leaf. Kernel and leaf tissue levels were highly correlated. Shriveling of the kernels was the main nut quality symptom associated with Cu deficiency. High rates of foliar or a combination of foliar and soil treatments may give the best results in young trees. Once trees are in production, the standard yearly Cu program for walnut blight control should provide adequate Cu deficiency correction.

## 245 (PS V)

## FOLIAR NUTRIENT-COMPOSITION OF DENDRANTHEMA GRANDIFLORA TZVELEV. 'SPEARS' IN RESPONSE TO INCORPORATED APPLICATIONS-OF CONTROLLED-RELEASED FERTILIZERS

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Recent studies at Louisiana State University evaluated incorporated rates (0.72, 1.08, and 1.44 kg

N/m<sup>3</sup>) of controlled-release fertilizers (Chrysanthemum Mix 12N-4.4P-14.1K, Osmocote 14N-6.1P-11.6K, and Nutricote Type 70 14N-6.1P-11.6K) on the foliar nutrient composition of 'Spears' potted chrysanthemums. Recently mature leaf tissue was sampled at flowering and analyzed for N, P, K, Ca, Mg, Fe, Zn, Cu, and Mn.

Increasing application rates reduced Ca and Mg content in leaf tissue, while N, P, and K increased with an increase in application rates. Chrysanthemum Mix 12N-4.4P-14.1K provided more K to leaf tissue than did Osmocote or Nutricote Type 70 14N-6.1P-11.6K.

## 246 (PS IX)

## USE OF FOAM IN STAND ESTABLISHMENT

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The concept of using Foam in agriculture is not new. Researchers at LSU in 1972 recommended Foam be used for; a carrier for insecticides and pesticides, frost protection agent, short-life mulch, evaporation suppressant and soil cover for fumigation. In 1974, Johnson Manufacturing Co., Pendleton, ND tested a light weight, low solids Foam as a frost protectant material on strawberries at the University of Maryland Research Farm, Salisbury, MD. Unfortunately, the Foam dissipated within 8 hours and was difficult to apply when winds were greater than 5 mph. In addition, equipment had not been developed to utilize the Foam technology in a field situation. In 1986, a new generation of Foam technology had been developed by Aqualon, Inc. and was initially tested in the spring of 1987 on several vegetable crops at the Horticulture Research Farm, Rock Springs, PA. The Foam was applied with a modified high pressure sprayer and banded over the seeded rows at a width of 10 cm and height of either 5 or 10 cm. Compared to bare-ground checks, there was no soil capping when the Foam was applied to carrots, beets, snap bean, broccoli, cucumber, lettuce and spinach. Generally, seeds emerged earlier and more uniform with the Foam treatments than the bare-ground checks. In addition, higher soil temperatures and moisture levels were observed under the Foam treatment. In the last 2 years, a prototype Foam Applicator was developed by Smucker Manufacturing, Harrisburg, Oregon.

## 247 (PS VII)

## INFLUENCE OF IN VITRO CONDITIONS ON GROWTH OF

IMMATURE EMBRYOS OF PEACH (*P. persica* (L.) Batsch).

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SH and MS media, sucrose concentrations (6% and 10%) and types of support (0.25% Gelrite, vermiculite and filter paper bridge) were compared in a factorial experiment to determine the effects on growth of immature embryos from peach cultivar B611505. Embryos were measured at the beginning of the experiment (control) and all treatments were kept in the dark at room temperature, for 40 days. Although gelrite, over all media treatments, increased embryos wet weight by 66%, the embryos were soft and succulent and their dry weight increased only 37%. Vermiculite support, on the other hand, increased wet and dry weights by 63% and 79%, respectively. Less embryo growth occurred with MS medium and filter paper bridge. Except for vermiculite and SH medium, 10% sucrose was more effective than 6% in increasing embryo growth.

## 248 (PS V)

## USE OF NON-DESTRUCTIVE IN VIVO SPECTROSCOPIC ANALYSES IN DETERMINING LEAF CHLOROPHYLL CONTENTS AND LIGHT ABSORPTION CHARACTERISTICS OF BEDDING PLANTS GROWN WITH DIFFERENT N SOURCE

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A non-destructive in vivo spectroscopic method for leaf chlorophyll (Chl) measurement was developed. Spectroscopic analyses of intact leaves of ageratum, petunia and salvia showed strong correlations between leaf light absorption at 723 nm and Chl-a contents. N H<sub>4</sub><sup>+</sup> increased Chl contents in both ageratum and petunia whereas NO<sub>3</sub><sup>-</sup> increased Chl contents in salvia. Plants fed with NH<sub>4</sub><sup>+</sup>+NO<sub>3</sub><sup>-</sup> also contained higher Chl. Chl-a/-b ratio in salvia was lowered by NO<sub>3</sub><sup>-</sup>. Ageratum, petunia and salvia grown with either NH<sub>4</sub><sup>+</sup>, NO<sub>3</sub><sup>-</sup>, or NH<sub>4</sub><sup>+</sup>+NO<sub>3</sub><sup>-</sup> were also examined for their light absorption characteristics. Light absorption at 705 nm by ageratum and petunia leaves was increased by N H<sub>4</sub><sup>+</sup> treatment. NH<sub>4</sub><sup>+</sup> is believed to have changed the structure of photosystem I in both ageratum and petunia but not in salvia. This result explain reasons for salvia's sensitivity to NH<sub>4</sub><sup>+</sup> fed as a sole N source.



249 (IX)

EFFECT OF TEMPERED WATER OF 50, 60, 70, AND 80 DEGREE F ON GROWTH AND DEVELOPMENT OF PETUNIA, IMPATIENS, VINCA, PANSY  
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Tempered water of 50, 60, 70, and 80 degrees F was applied to petunia 'Royal Cascade', Impatiens 'S.E. Pink', Vinca 'Little Bright Eye', and Pansy 'Majestic Giant Mix' during seed germination in the plug and in the pack. There was no effect on germination for any of the crops. The height of plug seedlings of petunia and pansy was inhibited by 50 degree F by as much as 20 percent. There was significant effects on plant size in the cell packs. A water temperature of 70 degrees F resulted in the largest plants in all crops. Height of petunia, impatiens, vinca, and pansy was reduced 20, 30, 32, and 49 percent at 60, 50, and 80 degrees F, respectively. Tempered water at 70 degrees F was ineffective in controlling plant height while water temperatures of 50 and 60 degrees F provided the best control of plant compactness. Fresh root weight for all plants was greatest at 70 degree F water. Fresh root weight was reduced 29% in petunias, 34% in impatiens, and 48% in pansy, all at 60 degrees F. Vinca fresh root weight was reduced 33% at 50 degrees F.

250 (PS VII)

DORMANCY EVALUATION UNDER THE SUBTROPICAL CONDITIONS OF NORTHERN MEXICO

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Mild, winter conditions vary greatly from year to year, and models to evaluate dormancy development have to separate between years to make accurate predictions for rest breaking purposes. The Utah Chill Unit model has been revised to incorporate time in the definition of chill units. A Chill Unit is redefined as equivalent to one hour at the optimal chilling temperature during the optimal chilling time. Mexico has 50,000 ha of apple trees that require rest breaking practices. Winter conditions of three contrasting years at two Mexican locations were analyzed by the original and revised Utah Chill Unit models. The original Utah model tends to overestimate chill unit accumulation under Mexican mild winter conditions. The revised model increased prediction accuracy of leaf development ten days after full bloom by 10% to within 1-2% of the observed values.

251 (PS V)

THE EFFECTS OF GROWTH REGULATORS ON FLOWERING, BRANCHING PATTERNS AND GROWTH OF NEW GUINEA IMPATIENS

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Eighteen New Guinea impatiens cultivars were evaluated for performance as bedding plants and for suitability as hanging basket plants. The cultivars were treated with three growth retarding chemicals (B-9, Sumagic and Cutless) to determine their effect on plant growth, branching and overall flower development. Two applications of 2500 ppm B-9 produced the most commercially acceptable plants. Height and spread were reduced by approximately 30 percent with no reduction in the number of flowers produced or the number of days to bloom. Cutless and Sumagic applications reduced growth approximately 50 percent and delayed blooming as much as 2 weeks when compared to the untreated control. Growth regulator treatment had no effect on the number of branches produced except with Sumagic which resulted in an overall reduction in branching.

252 (PS IX)

FERTILIZER SOURCE INFLUENCES GROWTH OF 'ANGELIKA RED' POINSETTIAS

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During 1988, N-chlorosis was a problem with 'Angelika Red' poinsettias in some parts of the Great Plains. A study was conducted with 'Angelika Red' poinsettias using one of 3 commercially available water-soluble fertilizers: 20N-9P-17K, 20-4-17, and 15-7-14. Plants were finished with either plain water or 15-9-21 (a commercially available poinsettia fertilizer). Data were taken when plants were marketable.

Fertilization with 20-9-17 resulted in reduced

stem dry weight in comparison to the other 2 production fertilizers. Bract display was reduced when 20-9-17 was used for production and plain water for finishing. Total foliar-N was greatest for this treatment indicating an accumulation of N H<sub>2</sub>-N. Production with 20-4-17 and finishing with either plain water or 15-9-21, or production with 15-7-14 and finishing with 15-9-21 produced plants with the greatest dry weights and inflorescences.

253 (PS VII)

EVALUATION OF DRIS-DERIVED CRITICAL LEVELS IN OREGON CRANBERRIES

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Cranberry (*Vaccinium macrocarpon* Ait.) is an important crop in Oregon. However, nutrient critical levels have not been established. Since developing nutrient critical levels usually requires time-consuming and expensive field trials, we chose to use the Diagnosis and Recommendation Integrated System (DRIS), which can use survey data to determine critical levels. We analyzed 139 cranberry samples collected from the southern Oregon coastal area over a three-year period. Leaf concentrations for N, P, K, S, Ca, Mg, Mn, Fe, Cu, B, and Zn in bearing uprights collected in mid-August were matched with the corresponding yields. DRIS was employed to obtain norms and critical levels from this survey data. To test our DRIS norms and critical levels, we evaluated two published experiments (Torio and Eck, 1969 and Medappa and Dana, 1969) where fertility treatments altered mineral concentrations and affected yield. Both ratio-based and critical concentration diagnoses were useful. Changes in the Nutrient Imbalance Index was a good predictor of yield response.

254 (PS V)

THE EFFECTS OF UNICONAZOLE ON PRODUCTION AND POSTPRODUCTION CHARACTERISTICS OF EASTER LILIES  
Linda S. Campbell\*, Timothy A. Prince, and Harry K. Tayama, Department of Horticulture, The Ohio State University, Columbus, OH 43210

Uniconazole (Sumagic) drench applications of 1.9, 2.7, and 3.8 mL per plant and spray applications of 10, 20, and 30 ppm resulted in shorter plants and more blasted flower buds compared to control plants. Drench applications also resulted in more chlorotic leaves than controls. Average lily height with Sumagic ranged from 19 to 29 cm after Sumagic drench and spray applications, respectively. Average plant height was 29 and 31 cm for ancymidol spray and drench application, respectively. Bud abortion was 10, 12, and 17% for spray treatments of Sumagic at 10, 20, and 30 ppm, respectively, while ancymidol spray caused no abortion. Bud abortions were 8, 7, and 11% from Sumagic drenches of 1.9, 2.7 and 3.8 mL/plant compared with 0% from ancymidol drenches. Plants drenched with Sumagic exhibited leaf chlorosis on day of bloom of 18, 16 and 16%, respectively, for the three respective rates of application while ancymidol caused 11.8% chlorosis. The number of buds initiated was not affected by the treatments. Further studies should be conducted to determine the effect of lower application rates of Sumagic on Easter lilies.

255 (PS IX)

WATER RETENTION IN SOILLESS POTTING MEDIA

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Water retention was measured in soilless potting media irrigated by capillary mat, flood and drain, drip or overhead sprinkler. Media were amended with wetting agent or hydrophilic polymeric gel. Pots 12 cm high with a volume of 465 cm<sup>3</sup> were loose-filled to the top with media. Potted media were wetted overhead with 120 ml water, then pots were randomly assigned to irrigation treatments. Capillary mat irrigation was continuous; other irrigation treatments were applied daily. Water retention was measured by weighing. Irrigation was continued until no further retention was measured. Water retention was significantly affected by irrigation method and medium amendments. Irrigation method followed the order overhead >= drip > flood and drain >= mat. Hydrophilic gel increased water retention, but in contrast to previous results, wetting agent did not, nor was any interaction of gel and wetting agent observed. Retention of water at container capacity, measured *in situ* at the end of each experiment, was significantly larger than actual retention.

## 256 (PS VII)

PHYSICO-CHEMICAL COMPARISONS OF PASSION FRUIT AND MAYPOP  
Harvey E. Arjona, Frank B. Matta\* and James O. Garner, Jr.  
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Physico-chemical characteristics of purple and yellow passion fruit (*Passiflora edulis* Sims.) were compared with those of maypop (*Passiflora incarnata* L.). Fruit diameter of maypop and purple passion fruit followed a typical sigmoidal growth curve. There were no differences in growth rate between the two species during the exponential phase. Growth differences, occurred after the exponential phase (10 and 20 days after anthesis). Fruits of the commercial types were heavier than greenhouse and wild grown maypop. Wild grown maypop produced heavier fruit compared to greenhouse grown maypop. Commercial passion fruit produced heavier rinds and greater pulp weight. Yellow passion fruit had the lowest percentage pulp and the most soluble solids. Greenhouse grown maypop had the lowest soluble solids. No differences in juice pH were found between the two species. Wild maypop fruits had the highest sucrose and greenhouse grown purple passion fruit had the lowest. Yellow and purple passion fruit had higher fructose than maypop. Glucose was significantly different between the two species, but not within species.

## 257 (PS V)

ENVIRONMENTAL AND SEED TREATMENT EFFECTS ON GERMINATION AND GROWTH OF INDIAN PAINTBRUSH

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Indian Paintbrush (genus *Castilleja*) is a group of attractive wildflowers in which some species are facultative parasites on native grasses during early growth. This study hopes to characterize optimum germination, cultural and host requirements of several species. Lots of 100 seed of wild-collected *Castilleja coccinea* (L.) Spreng. produced 22% germination without pre-treatment or presence of host plants 10 days after seeding at 21°C with 12 hours light. Seed soaked 24 hours in distilled water, 10 mg/l GA<sub>3</sub> or post-plant treated with Regal Crown nutrient and growth regulator solution did not significantly differ from above. Moist stratification at 4°C for 20 days significantly increased germination to 46%. Further stratification (up to 80 days) did not further increase germination. Additional data on light, temperature, media and presence of host plants will also be presented for this and other species.

## 258 (PS IX)

EFFECTS OF ATRINAL SPRAY ON BRANCHING AND GROWTH OF CHRYSANTHEMUM 'FORTUNE'

Hurriah H. Al-Juboory\*, University of Baghdad, College of Agriculture, Abu-Ghraib, Baghdad, IRAQ.

Three node stem cuttings of *Chrysanthemum* 'Fortune' were sprayed with Atrinal, 500, 1000, 1500 and 2000 ppm, to incipient runoff under greenhouse conditions. The results demonstrated that with higher levels of Atrinal, branch number, branch length, plant height, and flower number decreased in both unpinched and pinched plants. At the same time, the dry weight of both pinched and unpinched plants increased. Applications of Atrinal, 1000, 1500, and 2000 ppm, lengthened the number of days to flower by 40 days.

## 259 (PS VII)

MICROPROPAGATION OF THE HAZELNUT, *CORYLUS AVELLANA*

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Development of optimum protocols for micropropagation of *C. avellana* is particularly important due to the threat of Eastern Filbert Blight and the need for rapid increase of resistant varieties and advanced selections. Therefore, efforts were directed at in vitro establishment, multiplication and rooting, starting with buds from mature trees. The frequency of shoot formation from buds was highest in August but varied with the genotype. Medium containing high Ca levels was more effective in preventing bud necrosis than MS medium. Multiplication rates of 4-7

new shoots/propagule were obtained over a 6-week culture period. Rooting of some genotypes could be accomplished by inclusion of 1 or 3  $\mu$ M  $\beta$ -indolebutyric acid (IBA) in the medium. Other genotypes responded better to a dip of shoot bases in 1-10 mM IBA for 10 sec., followed by a passage on auxin-free medium. Large numbers of healthy plantlets have been produced for transfer to soil.

## 260 (PS V)

IN VITRO NUTRITION OF ALSTROEMERIA

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In vitro growth and development of *Alstroemeria* 'Cornell Pink' were evaluated on media containing different amounts of CaCl<sub>2</sub>, MgSO<sub>4</sub>, FeSO<sub>4</sub>, NO<sub>3</sub>, or NH<sub>4</sub>. Six levels of calcium chloride were originally examined (from 0 to 75 mM); the low levels proved to be most beneficial. Subsequent experiments used CaCl<sub>2</sub> levels from 0 to 3.0 mM. Again, the low levels were most productive. Two experiments, with different gelling agents, were designed for MgSO<sub>4</sub>. The levels ranged from 0 to 15 mM. The 15 mM level produced explants with the greatest fresh weight. Three experiments were used to study the effect of FeSO<sub>4</sub>. The range was the same in all of the experiments (0 to 1 mM), but the increments and the gelling agents differed. In all three experiments, the 1 mM level proved to be toxic. The group with treatments from 0.01 to 0.5 mM had the best response over time. Both experiments with nitrogen found no response to different NO<sub>3</sub>:NH<sub>4</sub> ratios. A positive linear response to rate was found within the range studied (20 to 80 mM).

## 261 (PS IX)

TRAINING AND PRUNING HEDGEROW ALMONDS

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In 1979 a Nonpareil-Price almond orchard, was planted 2.2m x 6.7m (270 trees/acre). Four pruning treatments were imposed on the hedgerow planting at the end of the first year. 1. Interplanted: Trees trained to 3 scaffolds then standard pruned 2nd-6th years. Alternate trees were whisked back during 7th and 8th years and whisked trees removed after 9th year. 2. Permanent Hedge: Trees trained to 3 scaffolds and standard pruned throughout. 3. Two Scaffold Hedge: Heavy 2nd and 3rd year training required to form 2 main scaffolds growing into the row middles then standard pruned. 4. Unpruned Hedge: Trees trained to 3 scaffolds then no further pruning. Treatment with alternate trees whisked back had 15% reduced yield each year following whisking. Removing these heavily pruned alternate trees at the 9th year then reduced yields an additional 30%. Now, three years after removal, yield still lags by 18%. Accumulating six years yield data shows no differences between the three treatment maintained as hedgerows. However, whisking and removing alternate trees resulted in 2000 lbs less yield over the 6 year period.

## 262 (PS VII)

RELATIONSHIP BETWEEN TEMPERATURE AND COLOR DEVELOPMENT IN THREE RED DELICIOUS APPLE STRAINS.

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The objective of this study was to determine the relationship between temperature and color development in 3 strains of Red Delicious apple (*Malus domestica* Borkh.). The strains 'Scarlett Spur', 'Ultrastripe' and 'Starkrimson' were chosen based on variation in coloration. Chromaticity values (L\* a\* b\*) were measured with a Minolta CR-200b colorimeter on 5 tagged apples on each of 4 trees of each strain. Measurements were made at approximately the same location on each fruit 23 times from July 11 through September 25, 1989. Differences in a\*/b\* ratio among strains were observed as early as the first sampling date; with 'Scarlett Spur' having the highest ratio and 'Starkrimson' the lowest. These differences were maintained for most of the growing season. Temperature below 21°C tended to enhance color development, whereas temperature above 21°C reduced coloration. Temperature affected all 3 strains similarly.

## 263 (PS V)

## ASEXUAL EMBRYOGENESIS AND PLANT REGENERATION FROM MALE CATKINS OF QUERCUS

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Partially expanded male catkins at the pre-pollen shedding stage of *Quercus rubra* L. and *Quercus bicolor* Willd. were cultured on MS medium supplemented with BA or 2,4D. Explants on 2,4D produced a yellow embryogenic callus, seeming to originate from the pedicels. Subsequent transfers to BA and then, MS without growth regulators, resulted in callus proliferation. After ten weeks in culture, white embryoids developed from the callus of *Q. bicolor*. Separated and individually cultured embryoids underwent direct, repetitive embryogenesis. Upon transfer to 1/2-strength MS, embryoid germination and plant regeneration occurred. Callus of *Q. rubra* degenerated after five months in culture, failing to produce embryogenic structures.

## 264 (PS IX)

## BIOLOGICAL PEST CONTROL WITH CONTINUOUS GREENHOUSE CULTURE

Anthony J. D'Angelo, Department of Entomology, Michigan State University, East Lansing, MI 48824 and James Quinn\*, Director of Greenhouse Operations, Willow Run Farms, Belleville, MI 48111.

A strategy for controlling pests with biological control was sought for production of salad greens and herbs in a nutrient film technique (NFT) growing system. A case study was initiated in October 1989 using a one half hectare greenhouse range (1988 construction) with no past or present synthetic insecticide use. Problematic pests were aphids and thrips. A natural predator/pest cycle (NPC) area was established (5% of total greenhouse area with potted herbs on benches) to provide an area for predators to establish and reproduce. Introduced predators, which successfully reproduced in the greenhouse, were *Apidoletes aphidimyza* (aphid control), *Amblyseius macKenziei*, and *A. cucumeris* (thrip control), *Encarsia formosa* (whitefly control), and *Phytoseiulus persimilis* (two spotted spider mite control). Naturally occurring predators of importance included a wasp parasitoid of aphids (Hymenoptera) and an insect predator, the minute pirate bug (Hemiptera, Anthocoridae), which feeds on thrips and aphids.

Two flying predators of aphids (*A. aphidimyza* and the wasp parasitoid) dispersed well from the NPC area and provided effective control. The technique of applying the thrips predators, a slow moving mite to flats shortly before transplanting provided good dispersal on all transplants. The time for effective control by the predator was 4 to 6 weeks. Effective control was observed in chives but not shorter cycle crops (3 to 5 weeks average). Immature minute pirate bugs were also observed in the chives assisting in control. Effective spider mite control was accomplished 2 to 3 weeks after the release of *P. persimilis* into infested area. Whitefly populations have been effectively controlled by *E. formosa*.

## 265 (PS VII)

## HORTICULTURAL AND ECONOMIC COMPARISON OF HAND VERSUS MECHANICAL PRUNING IN A HIGH DENSITY FRENCH PRUNE ORCHARD

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French prunes (*Prunus domestica* L.) on myrobalan seedling rootstock were planted in 1981 in an east-west direction with 4.9 m between rows and 2.7 m between trees on a poorly drained Class II soil in Glenn County, CA. A randomized complete block design was used with 8 trees per plot. Trees were pruned by hand to an open-center tree form or pruned by machine to a pyramid form in the dormant or summer season resulting in 6 pruning treatments. This high density system has led to high yields of good quality fruit (9.18 dry tons/acre in 1989, sized at 78 fruit per pound). Hand pruning led to higher yields, larger fruit, lower drying ratios and a greater dollar return per acre than any of the machine pruned trees. Dormant machine pruning led to larger fruit produced than those trees pruned in the summer by machine. Mechanical pruning may be possible for short time periods, but continued practice led to smaller fruit with lower yields than hand pruning. Certain locations within the tree canopy had smaller fruit size and it is within those lower locations where fruit size needs to be improved. These and additional experimental results obtained from 1987 through 1989 growing seasons will be presented.

## 266 (PS V)

## EFFECT OF FOLIAR FERTILIZATION AND SOME GROWTH REGULATORS ON GROWTH OF CROTON PLANTS

Mahmoud R. Shedeed, Khairy M. El-Gamassy, Mahmoud E. Hashim and Alaa M. Almulla\* Dept. of Horticulture, Faculty of Agriculture, Ain Shams University, Cairo, Egypt

The experiment was designed to investigate the effect of Fulifertil at levels 0.2 and 4 gm/L and growth regulators GA3 at 0,100,200 and 300 ppm also kinetin at 0,25,50 and 75 ppm and their combination on croton plants. The results indicate that there were increases in the plant height, leaves, number, leaf area and fresh and dry weight of vegetative growth. Spraying plants with 4 gm/L Fulifertil or 200 ppm GA3 or 50 ppm kinetin gave the best results specially with combined treatments.

## 267 (PS V)

## EFFECT OF FOLIAR FERTILIZATION AND SOME GROWTH REGULATORS ON THE CHEMICAL COMPOSITION AND THE PHOTOSYNTHETIC PIGMENTS OF CROTON PLANT LEAVES

Mahmoud R. Shedeed, Khairy M. El-Gamassy, and Alaa M. Almulla\* Dept. of Horticulture, Faculty of Agriculture, Ain Shams University, Cairo, Egypt

The experiment was designed to investigate the effect of Fulifertil at levels 0.2 and 4 gm/L and growth regulators GA3 at 0,100,200 and 300 ppm also kinetin at 0,25,50 and 75 ppm and their combination on croton plants. In general the results indicate that there were increases in the carbohydrates, nitrogen, phosphorus and potassium content. The anthocyanins and carotenoids pigments were increased while chlorophyll 'a' and 'b' pigments were decreased. These findings are required to give colorful leaves which give good display.

## 268 (PS IX)

## USE OF YARD WASTE COMPOST IN POTTING MIXES

Dennis B. McConnell\* and Wayne H. Smith, Department of Environmental Horticulture and Biomass Center, University of Florida, Gainesville, FL 32611

Three foliage plants, *Dracaena fragrans*, *Peperomia obtusifolia* and *Schefflera arboricola* were grown in 24 different mixes. Potting mixes were formulated using yard waste compost from two sources, a commercial mix (Metro 300) and a prepared mix (peat: pine bark sand). All potting mixes produced acceptable plants with no phytotoxicity associated with any mix. Only minor differences were discerned in the growth rate of *P. obtusifolia* and *S. arboricola*.

The growth rate of *D. fragrans* showed the greatest response to potting mix formulations. Plants in a standard potting mix (P/PB/S) used in the industry for *D. fragrans* grew slower than plants in many of the mixes containing various fractions of yard waste compost. Chemical and physical properties of the potting mixes used showed physical properties had the greatest variability. Overall, the best growth for all 3 plants was in a potting mix composed of 87.5% Metro 300/12.5% YWC#1 and worst growth was in YWC#2 (100% composted (live oak leaves)).

## 269 (PS VII)

## GROWTH SUPPRESSION IN DWARF AND SEMIDWARF APPLE ROOTSTOCKS BY UNICONAZOLE

J. Angel Saavedra\*, Elden J. Stang and Jiwan P. Palta, Dept. of Horticulture, University of Wisconsin, Madison, WI 53706

Uniconazole (UCZ) can control tree size by suppressing tree growth. Growth control of one year-old 'Haralred' on MAC 9 'MARK' (dwarf) and EMLA 7 (semidwarf) rootstock was evaluated in the greenhouse. Uniconazole (65 or 130 mg/L) was sprayed 0, 1, 2 or 3 times at 3 week intervals. Total shoot growth was inhibited 31% and 24% on 'MARK' and EMLA 7 rootstock, respectively, with 130 mg/L. Rootstock and scion diameter and number of leaves per tree were not affected by UCZ. Total leaf area on 'MARK' rootstock increased when UCZ was applied once at 65 or 130 mg/L. On EMLA 7 two 130 mg/L sprays resulted in 22% less total leaf area compared to the control. UCZ applied three times reduced specific leaf weight on EMLA 7 trees 12% compared to the control. Branch angle was increased proportional to UCZ applications on semidwarf rootstock from 40° to 47°, and decreased on dwarf rootstock from 47° to 39°. Stomatal conductance increased 43% on 'MARK' with 130 mg/L UCZ applied two times. Net photosynthesis of attached leaves did not differ. All UCZ treatments produced 18 to 56% fewer total flower clusters per tree than the control. UCZ appeared to delay bloom significantly.

## 270 (PS V)

## IN VITRO PROPAGATION OF VIRGINIA PINE FROM COTYLEDONS

Carole H. Saravitz\* and Frank A. Blazich, Department of Horticultural Science, and Henry V. Amerson, Department of Forestry, North Carolina State University, Raleigh, NC 27695

Adventitious shoots developed on cotyledons of Virginia pine (*Pinus virginiana* Mill.) excised from seeds germinated for 3, 6, or 9 days and cultured on media containing 0.5 to 10 mg/liter benzyladenine (BA). Shoot regeneration was greatest (46 shoots per embryo) on cotyledons from seeds germinated for 6 days and placed on medium containing 10 mg/liter BA. Shoots were excised and elongated on medium lacking BA. Following elongation, shoots were placed on media containing 0 to 40 mg/liter indolebutyric acid (IBA) for 14 days followed by transfer to the same medium lacking

auxin. Without IBA treatment, percent rooting was 3% and increased to 50% for concentrations of 5 to 40 mg/liter. Rooted shoots averaged 2.0 roots per shoot without auxin treatment, 3.3 roots when treated with 5 mg/liter IBA and root number increased linearly with increased IBA concentration up to 40 mg/liter (4.5 roots). Plant lets were transferred to growing medium and acclimated successfully to greenhouse conditions.

## 271 (PS V)

### HISTOLOGICAL EXAMINATION OF IN VITRO ADVENTITIOUS BUD DEVELOPMENT ON HYPOCOTYLS OF FRASER FIR

Carole H. Saravitz\* and Frank A. Blazich, Department of Horticultural Science, and Henry V. Amerson, Department of Forestry, North Carolina State University, Raleigh, NC 27695

Hypocotyls of Fraser fir (*Abies fraseri* (Pursh) Poir.) were excised from seeds germination 9 days and placed on bud induction medium containing 10 mg/liter benzyladenine (BA) and 0.01 mg/liter naphthaleneacetic acid (NAA) or medium without growth regulators. After 3 weeks. Cell clusters containing growth regulators, cell divisions were localized in epidermal and subepidermal layers of the hypocotyl while similar cell divisions were not observed in control-treated hypocotyls. Cell clusters consisting of two to five cells were present after 7 days in hypocotyls placed on bud induction medium. In control-treated hypocotyls, stomata continued to develop and cells within the cortex became vacuolated during the first 2 weeks in culture. All hypocotyls were transferred to secondary medium after 3 weeks. Cell clusters continued to enlarge into meristemoids in hypocotyls initially placed on bud induction medium. Gradually, meristemoids developed into buds and cataphylls were observed covering bud meristems.

## 272 (PS IX)

### ROOTING ACTIVITY OF NATURALLY DERIVED GROWTH REGULATORS: CYTOKIN AND ROOTS

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The possible loss of IBA for use in propagation of woody ornamental has prompted increased interest in the registration of phenyl indole-3-thiobutyrate (P-ITB), a potential alternative. Two products currently available, CYTOKIN and ROOTS, warrant investigation since ROOTS stimulates rooting of a few species (R. Poincelot, pers. comm.) and CYTOKIN is a similar product. Both contain naturally-derived cytokinin and algal extracts. The purpose of this study was to determine the rooting activity of these products utilizing the mung bean bioassay. Seeds of *Vigna radiata* 'Texsprout' were sterilized in 0.5% sodium hypochlorite for 10 min, rinsed, aerated for 24 hr in tap water, and then sown in coarse vermiculite (1 cm deep) held in plastic trays. Growth of the seedlings and the bioassay were conducted in a growth chamber under a 16-hr photoperiod, an irradiance of 85  $\mu$ E, 27.5°C during the day and 21.1°C at night. ROOTS enhanced rooting better than 0.1 mM NAA and was 68% that of 0.1 mM IBA. CYTOKIN at .2, 1, 2, 4, 5, or 10% did not stimulate rooting; additional concentrations are currently being tested.

## 273 (PS VII)

### SPUR PRUNING 'DELICIOUS' APPLE TREES

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Twenty-eight-year-old 'Starkrimson Delicious' trees were spur pruned in 1986 and 1987 and/or treated with BA + GA<sub>4+7</sub> in 1986 in an attempt to improve spur growth and fruit weight. Yield, fruit weight, and spur quality characters were recorded for 1986-1989. All treatment combinations failed to improve yield or fruit weight. Although spur-pruning improved spur length, spur bud diameter, leaf area per spur and leaf dry weight per spur, fruit weight was not improved. BA + GA<sub>4+7</sub> reduced yield and fruit weight, and increased the number of pygmy fruit in 1986, but had little effect on fruiting for the three years after treatment.

## 274 (PS V)

### EFFECT OF PLANTING DATE AND SOIL APPLICATIONS OF FUNGICIDE AND TRICHODERMA ON FLOWERING AND YIELD OF TWO STANDARD CARNATION CULTIVARS

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This study was carried out to determine the influences of planting date (June, July) and soil applications of

*Trichoderma harzianum* (strain T-95) and a fungicide containing ethazole + thiophanate (Banrot®) on flower production of standard carnation cvs. Improved White and Tanga. The one-year production data showed that the fungicide treatment increased flower yield by 7.3% (33.5 flowers/m<sup>2</sup>) and 4.8% (23.3 flowers/m<sup>2</sup>) in Improved White and Tanga, respectively, for June planting. Improved White produced more flowers and fancy grades when planted in July as compared to June planting. Planting date did not influence either the yield or the flower quality in Tanga. The effectiveness of *Trichoderma* as a biological control agent on flower yield and quality was not evident. The patterns of weekly flower production for the two cultivars were determined and graphically illustrated.

## 275 (PS V)

### TOXICITY SYMPTOMS OF MICRONUTRIENTS COPPER, MAGNESIUM AND ZINC FOR SELECTED BEDDING PLANTS

Chi Won Lee\*, Gye-Soon Jeong, and Byoung-Ryong Jeong, Department of Horticulture, Colorado State University, Fort Collins, CO 80523

Toxicity symptom of micronutrients copper, magnesium and zinc were investigated for geranium, marigold, vinca and zinnia. Plants were grown in peat-lite mix in 11 cm plastic pots and watered with nutrient solutions containing 0.05, 0.5, 1, 5, 10 mM concentrations of Cu<sup>2+</sup>, Mg<sup>2+</sup> and Zn<sup>2+</sup>. In most species, the concentrations of these micronutrients higher than 5 mM greatly reduced plant growth and induced stem and foliar toxicity symptoms. Toxic levels of Cu<sup>2+</sup> and Zn<sup>2+</sup> reduced plant and leaf sizes without producing leaf spots in all species tested. Toxicity symptom of Mn<sup>2+</sup> were characterized by numerous chlorotic or brown leaf spots. Visual leaf toxicity symptoms of these 3 micronutrients in each species are illustrated.

## 276 (PS IX)

### USING UNICONAZOLE TO CONTROL THE GROWTH OF VEGETABLE TRANSPLANTS IN A COMMERCIAL NURSERY PRODUCTION SYSTEM

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Seedling transplants produced for early fall and spring establishment of commercial vegetable crops in the Texas Lower Rio Grande Valley rapidly develop excessive shoot growth if field plantings are delayed. Therefore, several varieties of pepper, watermelon, muskmelon, and tomato transplants were treated at the 2-3 leaf stage by foliar spray with 0, 4, 8, or 12 ppm of the triazole growth retardant, uniconazole. The seedlings were field transplanted 3 weeks later. Total heights taken at the time of transplanting indicated significant varietal differences in responses to the treatments. After 60 days in the field, one of the 5 pepper varieties continued to express retarded growth. However, the uniconazole treatment stimulated early fruiting in 2 of the varieties. Tomato seedlings appeared to overcome the stunting within the first 60 days after transplanting while muskmelon and watermelon remained slightly dwarfed. Additional data on total growth and yield in response to the growth retarding treatments will be presented for each of the vegetable varieties.

## 277 (PS VII)

### PHOTOSYNTHETIC POTENTIAL OF SPUR LEAVES WITHIN AN APPLE CANOPY

Richard J. Campbell\* and Richard Marini, Department of Horticulture, Virginia Tech, Blacksburg, VA 24061

Light saturation curves were developed for detached, non-fruiting 'Stayman' and 'Delicious' spur leaves from interior, middle, and peripheral canopy positions throughout the season in 1989 and 1990, respectively. Be innings at bloom, measurements were made every 2 weeks for the first 8 weeks, and monthly thereafter. SLW was calculated simultaneously with photosynthetic measurements. MacArthur-Wilson saturation equations were used with non-linear regression to fit the saturation curves and SLW data, and curves were compared using indicator variables. Even at bloom, saturation curves and SLW differed among positions. The peripheral position had a greater saturation point and equilibrium rate throughout the season, and the interior and middle positions were equivalent by about 6 weeks after bloom.

278 (PS V)

**PETUNIA SEEDLING GROWTH - FLOWERING RESPONSE**

Will Healy\* and David Graper. Department of Horticulture, University of Maryland, College Park, MD 20742.

*Petunia* 'Red Flash' seedlings were grown under HPS ( $175 \mu\text{mol m}^{-2}\text{s}^{-1}$ ) photoperiod treatments of 10, 12, 14 or 16 hr at 20C soil temperature in a shaded glasshouse where the maximum peak PPF was reduced to  $150 \mu\text{molm}^{-2}\text{s}^{-1}$ . Seedling were transplanted after they had unfolded a specific number of leaves and grown under natural days or placed under photoperiod treatments which consisted of an 8 hr natural day with incandescent day extension treatments of 1 to 6 hours.

A 16 hr HPS treatment decreased the days to transplant (DTT) by more than 4 days and reduced the days from transplant to flower (DTF) by more than 5 days. The total reduction in days from sowing to flower (DSTF) was at least 8 days. When compared to unlighted controls, the reduction in DSTF was 26 days. The longer the seedlings remained under the HPS treatments, the shorter the DTF and DSTF. Premature shifting of plants to natural days resulted in up to a 9 day delay in DSTF. At photoperiods greater than 13 hr, the number of nodes subtending the inflorescence becomes constant regardless of number of leaves at transplant.

279 (PS V)

**FLOWERING OF *AESCHYNANTHUS* 'KORAL' UNDER DIFFERENT PHOTOPERIOD AND TEMPERATURE REGIMES**  
Brooks Whitton and Will Healy\*, Department of Horticulture, University of Maryland College Park, MD 20742

*Aeschynanthus* 'Koral' plants were grown in photoperiods of 8 to 14 hr (8 hr natural daylight plus 0-6 hr incandescent light of  $3 \mu\text{molm}^{-2}\text{s}^{-1}$ ) beginning January, March, or June. The number of weeks to anthesis and number of leaves on shoots reaching anthesis were not affected by photoperiod, but differed when treatments began. Number of shoots reaching anthesis per plant was greatest in photoperiods of 13 hr for treatments beginning January or June. Time of year influenced flowering more than photoperiod, suggesting a temperature interaction. A. 'Koral' plants were given photoperiods of 12 or 24 hr (daylight fluorescent lamps at 100 or  $50 \mu\text{molm}^{-2}\text{s}^{-1}$  respectively) at temperatures of 18 or 24 C. After 8 weeks, 18 C plants had fewer nodes before the first flower bud than 24 C plants. Number of nodes to the first flower bud was decreased under the 24 hr treatments at 24 C, while no difference to photoperiod was observed at 18 C. Flowering of A. 'Koral' appears to be promoted by 18 C temperature where the plant behaves as a day neutral plant. At 24 C, A. 'Koral' responds as a long day plant.

280 (PS V)

**PETUNIA SEEDLING GROWTH - HPS PHOTOPERIOD STUDY**  
Will Healy\* and David Graper. Department of Horticulture, University of Maryland, College Park, MD 20742

*Petunia* 'Red Flash' seedling were grown under HPS ( $175 \mu\text{molm}^{-2}\text{s}^{-1}$ ) photoperiod treatments of 10, 12, 14 or 16 hr at 20C soil temperature in a shaded glasshouse where the maximum peak PPF was reduced to  $150 \mu\text{molm}^{-2}\text{s}^{-1}$ . Seedling dry weight and individual leaf area were determined daily. The photosynthetic rate was determined when seedlings reached the second true leaf stage.

The dry weight response to increasing photoperiod durations was cubic with a peak at 14 hr. Seedling dry weight increased slowly during days 5 through 10 then increased rapidly during the next 7 to 10 days. This increase coincided with the unfolding of leaves one through four. The total leaf area showed a cubic response to the photoperiod treatments. The leaf area increased slowly then began an exponential increase after day 10. The photosynthetic rate per gram dry weight was increased by the 10 hr photoperiod treatment when compared to the 16 hr treatment. The increased photosynthetic rate was not observed when the data was calculated on a fresh weight or leaf area basis.

281 (PS IX)

**SMALL- SCALE, LOW-COST FILTERS FOR DRIP IRRIGATION SYSTEMS**  
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Drip irrigation systems are used extensively by commercial vegetable producers. Such systems permit precise water placement and efficient water utilization. Emitters in drip irrigation lines can easily become clogged if water supplies contain solid particles. Most farm water is not

suitable for drip irrigation unless filters are used to remove solid particles from the water. Small scale or part time vegetable producers often find the cost of conventional filter systems to be a substantial financial investment.

A filter which is small, lightweight, and portable was designed, built, and tested. The system is constructed from standard hardware and plumbing materials that can be purchased for less than \$50. Construction time is four hours or less. The filter system works well for small scale operations that require low flow rates of water.

Specifications for construction, including a materials parts list and construction details will be presented.

282 (PS VII)

**A PRELIMINARY COMPARISON OF 'GALA' APPLE TREES ON A RANGE OF SIZE-CONTROLLING ROOTSTOCKS**

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'Gala' apples are increasing in worldwide popularity. Despite this, little information on the cultivars vigor, precocity, or interaction with size-controlling rootstock is available. In 1985, a factorial planting was set to study these variables. 'Gala' and 'Golden Delicious' trees were found similar in precocity. Cumulative yields were about 20 kg per tree after the fifth leaf. 'McIntosh' and 'Delicious' trees were less precocious. 'Gala' trees were also quite vigorous. Tree size and yield efficiency data will be presented, comparing 'Gala' with other cultivars budded onto M 7a, MM 111, or propagated in tissue culture as scion-rooted plants. Tree management techniques have been identified that decrease fruit size. Trees budded onto precocious rootstock, and fruited heavily on one-year wood produce small-sized fruit. This tendency is pronounced on trees fruiting in the second leaf, or on older trees damaged by late-spring freezes that reduce the proportion of crop borne on spurs.

283 (PS V)

**AIR LAYERING FOR CLONAL PROPAGATION OF PROSOPIS CHILENSIS AND OTHER WOODY DESERT LEGUMES**

Randall H. Hagen\* and David A. Palzkill., Department of Plant Sciences, University of Arizona, Tucson, AZ 85721

Woody legumes used for landscape plants in the desert southwest are extremely variable when propagated from seed. Three *Prosopis chilensis* trees were air layered in early April, 1989. Stems diameters of 0.5 and 1.0 cm and IBA levels of 5,000 and 15,000 ppm IBA were compared. Except when mechanical damage occurred during the wounding stage or from wind, 100% of the layers at both 5,000 and 15,000 ppm IBA rooted. The 0.5 cm branches were more susceptible to mechanical damage from wounding than the 1.0 cm branches.

A second study begun in mid-August, 1989, compared 0 and 5,000 ppm IBA on the same three genotypes. After eight weeks, IBA treated layers had 83% and untreated layers only 13% rooting. Layers with IBA had thicker and more numerous roots.

Air layers of *Cercidium*, *Parkinsonia*, and other species of *Prosopis* were also successfully rooted.

284 (PS V)

**ASEXUAL PROPAGATION OF 'DESERT MUSEUM' HYBRID PALO VERDE AND MESQUITE SPECIES UNDER INTERMITTENT MIST**

Randall H. Hagen\* and David A. Palzkill., Department of Plant Sciences, University of Arizona, Tucson, AZ 85721

The 'Desert Museum' hybrid between the Blue, Foothills, and Mexican palo verdes has been well received by the public. However, it has remained unavailable due to difficulties in asexual propagation. Studies were conducted on effects of IBA cone. (0 to 10,000 ppm), cutting position along the stem, size of cutting, season, and temperature of the medium.

For 'Desert Museum', basal cuttings of slightly hardened new stem growth rooted much better than apical cuttings. Best rooting for apical cuttings was 79% using IBA from 2,500-5,000 ppm. Basal cuttings averaged 95% rooting and showed no response to IBA. Rooting of cuttings taken in September declined to 10% for apical and 2170 for basal cuttings averaged over all IBA levels. Six other species or hybrids of *Cercidium* and *Parkinsonia* and five of *Prosopis* were also rooted.

285 (PS IX)

POTTED GERANIUM (PELARGONIUM  $\times$  HORTORUM)  
GROWTH WITH LEACHING FRACTIONS OF O to 0.4

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Geranium 'Yours Truly' in 15-cm diameter plastic pots were greenhouse-grown as single pinched plants in a completely randomized design. Plants were irrigated with 300 mg/liter N from 20N-4.4P-16.6K with leaching fractions (LF) of 0, 0.1, 0.2, and 0.4. There were 24 irrigations during the 8-week study. Plants with LF of 0.2 and 0.4 had 46% greater leaf area, 40% greater top fresh weight, and 37% greater top dry weight than plants with LF of 0 and 0.1. By week 5 the leachate electrical conductivity (EC) for LF of 0.1, 0.2, and 0.4 had increased from about 3 dS/m initially to 12, 8, and 4 dS/m, respectively. At harvest, medium EC<sub>s</sub> was 7, 4, 3, and 2 dS/m for LF of 0, 0.1, 0.2, and 0.4, respectively. At harvest, medium pH was the same in the top, middle, and bottom thirds of the pot. At harvest medium EC<sub>s</sub> with LF of 0.1, 0.2, and 0.4 was 47, 68, and 60% lower in the bottom two-thirds of the pot than in the top third. With a LF of 0 the medium EC<sub>s</sub> was not lower in the bottom of the pot. Minimizing the LF for potted geraniums substantially reduced plant growth.

286 (PS VII)

RESPONSES OF FOUR PRUNUS PERSICA CULTIVARS  
BUDDED ON 'NEMAGUARD' AND THE BRAZILIAN  
ROOTSTOCK 'A82'

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32344

Trees budded on the Brazilian rootstock 'A-82' have a lower feeding preference by the primary vector of Phony peach disease over trees on 'Nemaguard'; the southeastern industry standard rootstock. 'A-82' budded trees have lower levels of infection of the xylem-limited bacteria *Xylella fastidiosa* compared to 'Nemaguard' budded trees.

The feasibility of using 'A-82' in the industry was evaluated by budding 'Flordaking' and 'Flordaglobe' peach and 'Sungem' and 'Armking' nectarine to 'A-82' and 'Nemaguard'. Vegetative and fruiting responses of these trees will be discussed.

287 (PS IV)

EFFECTS OF TALL FESCUE TURF ON GROWTH AND  
NITROGEN FIXATION POTENTIAL OF THE WOODY LEGUME  
*LUPINUS ALBIFRONS*

Lin Wu\* and Armando Torres, Department of Environmental  
Horticulture, University of California, Davis, CA 95616

The effect of tall fescue turf on growth, flowering, modulation, and nitrogen fixing potential of *Lupinus albus* Benth. was examined for greenhouse and field grown plants. No allelopathic effect was observed for lupine plants treated with tall fescue leachates. The nitrogen-fixing potential measured by nodule dry weight and acetylene reduction rates was not significantly affected by either tall fescue turf or low nitrogen fertilization. Both the greenhouse and field studies showed that the growth, sexual reproductive allocation, and number of inflorescences were significantly reduced when lupine plants were grown with tall fescue. The root length densities of tall fescue turf and lupine monoculture were measured. The tall fescue turf had 20 times higher root length density (20 cm cm<sup>-3</sup> soil) than the lupine plants monoculture. This suggests that intense competition at the root zone may be a dominant factor which limits the growth of the lupine plants. The reproductive characters of the lupine plants was improved by phosphorus fertilization. Transplanting of older lupine plants into the turf substantially alleviated the tall fescue turf competitive effect.

288 (PS IX)

EVALUATING STRUCTURELESS OVERWINTERING SYSTEMS FOR CONTAINER-  
GROWN HERBACEOUS PERENNIALS

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A major limiting factor in producing container-grown herbaceous perennials is low-temperature injury to cold sensitive roots and crowns during above ground winter storage. Growers and retailers of these plants understand the need for protection systems, yet specific recommendations are unavailable. The ability of several structureless systems to

moderate temperature and protect 16 species of container-grown herbaceous perennials from low-temperature injury was investigated. Two light-excluding treatments consisting of 30 cm of straw between 2 layers of 4 mil white copolymer, and 18 cm deep in-ground beds protected with 1 layer of 4 mil white copolymer and 30 cm of woodchips provided the greatest moderation of winter low and early spring high temperatures but resulted in severe etiolation among test plants. A bonded white copolymer-microform overwintering blanket with translucent properties provided comparable plant survival, and prevented etiolated growth allowing plants to grow rapidly after uncovering, despite dramatic temperature extremes observed beneath this cover.

289 (PS VII)

DIFFERENCES IN CHILLING AND POST-REST HEAT REQUIREMENT OF  
VARIOUS PRUNUS SPECIES AND PEACH CULTIVARS (P. PERSICA L.  
BATSCH)

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Differences in chilling and post-rest heat requirements of various stonefruits were investigated through the use of cuttings collected from field grown trees. Materials studied included *P. angustifolia* Marsh, *P. besseyi* Bailey, *P. maritima* Marsh, *P. persica* (L.) Batsch ('Agua 6-4', 'Flordaking', 'Pi Tao', 'Redhaven', 'Redskin', and 'Ta Tao'), *P. umbellata* Ell. and a Japanese type plum ('Byrongold'). Cuttings were collected after natural leaf fall and shortly after the onset of of chill hour accumulation. Cuttings were stored at 4°C. Groups of cuttings were removed from storage after various amounts of chilling and allowed to develop at 16, 21 or 27°C. Cuttings were observed for both vegetative and flower bud break. Magnitude of differences in chilling and post-rest heat requirements and their implications in the breeding of peaches for low and moderate chill areas will be discussed.

290 (PS IV)

SEEDLESS WATERMELON CONSUMER PREFERENCE SURVEY

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Several new seedless watermelon cultivars have recently been released or tested by seed companies. Their greatest asset is their seedlessness. Melon quality, as determined by consumer acceptance may be a greater challenge.

A consumer preference survey was conducted to determine the acceptability of ten seedless cultivars and breeding lines. All cultivars were rated as acceptable and significant differences were found among the cultivars. Comments expressed by consumers indicated that the seedless melons were not as flavorful as seeded cultivars. No correlations were found between soluble solids and preference nor firmness and preference. Further investigation will be made as to whether the convenience and flavor are worth the greater cost of the seedless watermelon.

291 (PS IX)

TOLERANCE OF ORNAMENTAL GRASSES TO POSTEMERGENCE  
GRASS HERBICIDES

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Ornamental grasses are popular landscape plants and often encounter turf encroachment or other grass weed problems. Several postemergence grass herbicides are available for use in turf and ornamentals and herbicide tolerance information is needed for ornamental grass species. Fifteen ornamental grasses including species from the genera *Calamagrostis*, *Cortaderia*, *Eragrostis*, *Erianthus*, *Miscanthus*, *Sorghastrum*, *Spartina*, *Panicum* and *Pennisetum* were field planted in Clemson, SC in May 1989 and *Festuca* species in November, 1989. Herbicide treatments were fenoxaprop-ethyl, fluazifop-P and sethoxydim at 0.4 kg a.i./ha<sup>1</sup> applied 4 weeks after planting and an untreated control. Height and injury evaluations were taken at weekly intervals and plants were harvested 10 weeks after treatment. Fenoxaprop-ethyl treated *Calamagrostis* and *Festuca* species treated with all herbicides were the only treatments that were the same as untreated controls in terms of % injury, height and dry weight. Three ornamental *Calamagrostis* species were evaluated in a greenhouse study to determine the level of tolerance to fenoxaprop-ethyl at 0.4, 0.8, 1.6 and 3.2 kg a.i./ha<sup>1</sup>. No visual injury symptoms were seen on any treatments as compared to untreated controls but growth rates of the youngest leaves did vary among species shortly after treatment.

## 292 (PS VII)

DIURNAL CHANGES IN LEAF CONDUCTANCE AND WATER RELATIONS IN *FRAGARIA CHILOENSIS* AND *F. VIRGINIANA* FOLLOWING WATER DEFICIT STRESS  
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Plants of *F. chiloensis* cv. BSP14 (FC) and *F. virginiana* cv. NCC85-13V (FV) were stressed until wilting, then watered for 2 days prior to measurement. Diurnal measurements of leaf conductance and water relations were conducted. Leaf conductance of stressed FC plants was generally lower, than that of controls at most times, but there was no difference between the two in FV. Leaf conductance and transpiration rates had not fully recovered to pre-stress levels within this recovery period. Leaf water potential declined from predawn to midday, more in stressed than control plants of both species. Leaf osmotic potential averaged 0.4 and 0.2 MPa lower in stressed than control FC and FV plants, respectively. Greater differences occurred at midday than predawn. Leaf pressure potential of stressed plants was higher predawn than midday, 1.4 vs. 0.7 MPa, in FC; it was not different for FV at most times. The difference in water relations between these two species may be explained by a greater residual effect from the osmotic adjustment in FC as compared to FV that occurred during prior water deficit stress.

## 293 (PS IV)

COMPARISON OF THE DIFFUSIVE RESISTANCE OF POLYETHYLENE GLYCOL TREATED AND NON-TREATED TISSUE CULTURE TOBACCO PLANTLETS

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Detached and intact leaves (first fully expanded leaf from the top) of tobacco (*Nicotiana tabacum* L.) plantlets hardened in vitro with 2.0% polyethylene glycol (PEG) showed increased diffusive resistance ( $r$ ) over those of nonhardened plantlets as measured by a steady state porometer. The leaves of the PEG hardened plants maintained a higher resistance throughout the one hour desiccation period in approximately 30% relative humidity, although both treatments showed an increase in diffusive resistance after 30 minutes. This indicates that the stomates are functioning in the in vitro tobacco plantlets. The higher ( $r$ ) in the PEG treated plants may be due to more complete closure of stomates, higher cuticle wax content or a combination of both.

## 294 (PS IX)

SPUNBONDED FABRIC COVERS ALTER EARLY SEASON GROWTH AND FRUIT SET IN CRANBERRY

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Spunbonded polypropylene fabric covers were applied over mature 'Searles' cranberry (*Vaccinium macrocarpon* Ait. in the field during dormancy in 1989. Covers were selectively removed at 3 week intervals in April, May and early June after onset of growth. Plant canopy air temperatures under fabric were 5 to 6°C higher than in exposed controls. Temperature differences up to 17°C were measured in early June. Soil temperatures did not differ from the control until late May. Earlier greening of leaf tissue resulted in increased photosynthetic rates earlier in the growing season under fabric covers. Subsequent shoot dry weight was increased 5%; leaf size was not affected. A trend to increased fruit set (4 to 6%) with fabric cover treatments was observed when covers were applied for 6 or 9 weeks. Total fruit yield and anthocyanin content were not appreciably influenced by fabric covers.

## 295 (PS VII)

EFFECT OF RACEME THINNING AND GIRDLING ON FRUIT SET OF MACADAMIA NUT

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Premature fruit drop of *Macadamia integrifolia* is a major limitation to yield. This study investigated the effects of raceme thinning and branch girdling on final fruit set of macadamia nut 'Ikaika' and 'Keau'. Eleven-year old grafted trees grown near Hilo, Hawaii were used. Racemes were thinned to 1, 2, or 4 racemes per branch two weeks after anthesis. The base of half these branches was girdled when the racemes were thinned.

Premature fruit drop occurred during the 97 and 151 days following anthesis for 'Keau' and 'Ikaika', respectively. Peak fruit drop occurred within 70 days after anthesis for both cultivars. Raceme thinning and girdling had no effect on final fruit set (nuts/branch) of 'Ikaika' 151 days after anthesis. There was a significant interaction between raceme thinning and girdling on final fruit set of 'Keau'. Branches with four racemes set more fruit than branches with one or two racemes. Raceme thinning and girdling had no effect on fruit retention (% of initial fruit set retained through

final fruit set per branch) of 'Ikaika'. There was a significant interaction between girdling and raceme thinning on fruit retention of 'Keau'. Branches with four racemes had greater fruit retention than branches with one or two racemes. Premature fruit drop may be altered on individual branches by altering raceme load and limiting phloem transport of assimilates into the girdled branch.

## 296 (PS IV)

A SIMPLE METHOD TO CONTROL HUMIDITY IN SMALL EXPERIMENTAL CHAMBERS

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Humidity is an important component of the environment that influences the growth, development and storage life of most horticultural crops. A method to control relative humidity (RH) in experimental chambers using solutions of glycerol-water has been developed. A constant RH can be established and maintained by bubbling air through a glycerol-water solution of known water content. The air rapidly reaches equilibrium with the glycerol-water solution producing the desired RH. The relationship of the specific gravity (SG) of glycerol-water solutions and the corresponding equilibrium RH was determined. Any desired RH can be produced by using solutions of the appropriate SG ranging from 100% with pure water (SG 25/25 = 1.000) to 0% with pure glycerol (SG 25/25 = 1.261). This system can be used in flow through systems by bubbling the incoming air through the solution or in closed systems by circulating air through the solution and the chamber. Multiple jars of solution can be used for more precise RH control. The effects that temperature and atmospheric pressure in the jars have on the equilibrium RH will be discussed.

## 297 (PS IX)

RESPONSE OF FIVE BEDDING PLANT SPECIES TO PACLOBUTRAZOL AND THREE COMMERCIAL GROWTH RETARDANTS

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Paclobutrazol and three commercial growth retardants (B-nine, Cycocel and A-rest) were compared for their effectiveness in controlling the growth of five bedding plant species ('Yellow Boy' marigold, 'Blue Blazer' ageratum, 'Dreamland Orange' zinnia, 'Better Boy' tomato and 'Black Beauty' eggplant). Results showed that growth suppression depended on the treatment and species tested. All of the growth retardants suppressed the growth of 'Yellow Boy' marigold. Growth of 'Blue Blazer' ageratum was suppressed by all the treatments except for Cycocel. With 'Dreamland Orange' zinnia, B-nine and Cycocel suppressed growth while Paclobutrazol and A-rest did not have any effect. All of the treatments except A-rest suppressed the growth of 'Better Boy' tomato and 'Black Beauty' eggplant.

## 298 (PS VII)

RESPONSE OF APPLE SHOOT CULTURES TO COLD TREATMENT

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Established shoot cultures of three apple genotypes, 'Dayton', 'McIntosh', and 'Golden Delicious' were subcultured into culture tubes containing a modified MS medium and maintained in a dark chamber at  $1.0 \pm 0.5^\circ\text{C}$  for periods of 3, 6, 9, and 12 months. Following each cold storage period, culture tubes of each of the three genotypes were transferred to a growth room and maintained under 16 h of light ( $60 \mu\text{Es} \cdot \text{m}^{-2}$ ) and  $21^\circ\text{C}$ . The overall morphological condition of each shoot was then recorded. After 4 weeks of growth, both number and length (in cm) of proliferating shoots were recorded. In general, shoots subjected to 3 or 6 months of cold storage remained green however most cultures did not initiate any new shoots. Cultures subjected to 9 or 12 months of cold treatment were etiolated however new axillary shoots were observed. The proliferation rate after 4 weeks of growth under standard growth conditions were variable among the different genotypes. The implications of using long term cold storage of apple shoot cultures will be discussed.



299 (PS IV)

SUPPRESSING RHIZOME GROWTH AND TUBER FORMATION IN PURPLE NUTSEDGE BY PACLOBUTRAZOL

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Purple nutsedge is a difficult weed to eradicate due to extensive underground growth. One eradication strategy is to inhibit tuber formation for preventing reproduction. In developing this strategy, soil applications of paclobutrazol (PA) were conducted to suppress rhizome and tuber development in Hawaii. Factors examined were 4 PA levels at 0, 0.5, 2 and 8 mg ai-liter<sup>-1</sup> (medium) and 4 application types: a) soil drench, fresh tuber, b) soil incorporation, fresh tuber, c) soil drench, stored tuber for 1 month at 4C, and d) drench to a synthetic medium (vermiculite : perlite = 2:1 by volume), fresh tuber. Treatment design was 4x4 factorial with 5 replications, and experimental unit was a tuber planted 2 cm deep in a 1-liter plastic container. Two months after planting tuber numbers and rhizome lengths were recorded and analyzed for regression and orthogonal comparisons. Control means were 11.1 tubers and 1178 mm total rhizome length. PA reduced both measurements as no tuber was formed at 2 or 8 mg ai-liter<sup>-1</sup> and total rhizome lengths were limited to 8 and 3 mm, respectively. PA was less effective in the synthetic medium than in the soil, while application methods and tuber storage did not result in significant differences.

300 (PS IX)

BLUEBERRY-BUNCHBERRY INTERACTIONS IN LOWBUSH BLUEBERRY

FIELDS. D.E. Yarborough\*, University of Maine, Orono, ME 04489 P.C. Bhowmik, University of Massachusetts, Amherst, MA 01003

Bunchberry (*Cornus canadensis* L.) is increasing in density and distribution in lowbush blueberry fields (*Vaccinium angustifolium* Ait.) in Maine and Nova Scotia. Replacement series experiments to assess competitive effects of bunchberry were established on native stands of blueberries at Blueberry Hill Farm in Jonesboro, ME in 1986 and 1987. Ten 0.42 M<sup>2</sup> quadrats were established on prune and crop fields with cover ratings where c=crop, blueberry and w=weed, bunchberry at 100c/0w, 75c/25w, 50c/50w, 25c/75w, 0c/100w. Dormant blueberry and bunchberry plugs from prune fields were transplanted into five, 0.42 M<sup>2</sup> boxes at 16 plugs/box in the above proportions in April 1987 and grown in the greenhouse over the summer in Orono, ME. Regression of individual vs associate yield indicates blueberry and bunchberry equivalent in competitive ability. Blueberries are competitive with bunchberry but in native fields open areas among clones allow faster growing bunchberry to spread without competition.

301 (PS VII)

A STUDY OF FLOWER BUD DIFFERENTIATION IN SWEET CHERRY BY SCANNING ELECTRON MICROSCOPE

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Buds from 12-year-old 'Bing' sweet cherry trees were collected biweekly from May 25, 1989 to August 31, 1989 and periodically thereafter until the spring of 1990. Buds were partially dissected by removing outer bud scales, then fixed in a solution of 3% glutaraldehyde and 2% formaldehyde for 24 hrs. The buds were then stored in phosphate buffer solution at 6.8 pH at 4C for a maximum of 6 months. Buds examined with the SEM were critical point dried, mounted and coated with gold. Anthesis occurred April 28 and fruit were harvested July 6. Rapid changes in the development of the buds occurred during the period between July 7 and July 20. Flower primordia were just barely visible on July 7 in the most advanced buds but by July 20 multiple flowers were visible with sepal primordia apparent. By Aug 3 petals were clearly defined and stamen primordia evident. By August 17 anthers were clearly visible and pistil primordia were evident. Most buds produced 2 flowers with some producing a third. The third flower trailed the other two buds in development.

302 (PS IV)

EFFECT OF 2,4-D LEVEL AND NODAL POSITION ON THE CALLUS INITIATION OF NODAL SEGMENTS OF BUCHLOE DACTYLOIDES (NUTT.) ENGELM.

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Stolon nodal segments of *Buchloe dactyloides* (Nutt.) Engelm. were removed from greenhouse grown plants and placed

on Gamborg's B<sub>5</sub> medium in order to determine nodal position and 2,4-D level required to give maximum callus initiation. 2,4-D levels used were 5uM, 16uM, 35uM, and 50uM. Six nodal segments were grouped according to position on the stolon, from the most recent node (node one) to the basal node (node 6). It was concluded that node 4 gave statistically greater callus mass than nodes 1, 2, 3, 5, and 6. Increasing levels of 2,4-D suppressed callus initiation, with maximum response occurring at 5uM 2,4-D.

303 (PS IX)

INCREASED YIELDS AND ETHYLENE PRODUCTION OF MECHANICALLY STRESSED WITLOOF CHICORY

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Yields and quality of witloof chicory are often low when roots are forced following several months storage or when forced at high temperatures. A technique was developed to improve the yield and quality of the chicory forced hydroponically and a method developed to determine the rates of respiration and ethylene production during the application of the technique. The technique involves the use of a resilient material (polyurethane) combined with the application of pressure to the developing chicory. Marketable yields and density of 'Faro' and 'Bea' chicory increased with increasing pressure applied. Increasing pressure also resulted in a significant decrease in the length to diameter ratio of chicory, an indicator of improved quality. Mechanical pressure resulted in a 3 to 4 fold greater increase in ethylene production than the control. Respiration rate increased to about twice that of the control after 10 days forcing and thereafter declined slightly. The technique provides a tool for improving economic yields of hydroponically forced witloof chicory. A possible physiological explanation for the technique is provided.

304 (PS VII)

CHILLING REQUIREMENTS OF HAZELNUT CULTIVARS

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Chilling requirements of 44 genotypes of *Corylus avellana* L. were estimated by cutting shoots in the field at weekly intervals and forcing them in a warm greenhouse for four weeks. The chilling requirements of catkins, female flowers, and leaf buds were assumed to have been met when development occurred on more than half of the respective plant parts. Chilling requirements were lowest for catkins and highest for leaf buds, and ranged from <100 to 860 hours for catkins, 290-1550 hours for female flowers, and 365-1395 hours for leaf buds. The lowest chilling requirements were observed for the leading cultivars of Turkey and southern Italy. The yellow-leaved ornamental *C. avellana* var. *aurea* had very high chilling requirements for all plant parts.

305 (PS IV)

MUTATION, A MICROCOMPUTER MODULE DESIGNED FOR PLANT BREEDING AND GENETICS

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A teaching module was developed for computer-aided instruction of mutation theory. The Hypercard-driven, Macintosh compatible module illustrates the concepts of: 1) Changes in allele frequency with mutation pressure; 2) Number of alleles maintained in populations, and; 3) The Neutrality Hypothesis. The concepts are integrated in an application by using a game format.

Mutation is the ultimate source of genetic variation. Mutation pressure results in changes in allele frequency. Concept 1 illustrates the theoretical changes in allele frequency under pressure of reversible mutation. Mutation equilibrium is depicted as  $P = V/u + v$ ; where  $v$  = mutation rates of allele A and  $u$  of allele a. The Infinite-Alleles Model of mutation is illustrated in Concept 2 and specifies characteristics of new mutations by  $F = 1/4Nu + 1$ , where  $F$  = fixation index and  $N$  = number in population. Concept 3 demonstrates the hypothesis that polymorphisms result from selectively neutral alleles maintained in a balance between mutation and random genetic drift.

306 (PS IX)

#### EUSTOMA GRANDIFLORUM RESPONSE TO pH OF GROWING MEDIA

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Symptoms of foliar chlorosis or bleaching, interveinal chlorosis of lower leaves, leaf edge and tip necrosis, stunted growth and delayed flowering of Eustoma increased as pH decreased below 6.5 in various peat-vermiculite based media for all cultivars tested. Symptoms were evident with or without microelement amendments in the media or fertilizer. A 5x5 factorial with pH of media and fertilizer solutions ranging from 5.1 to 7.5 indicated fertilizer pH did not negate plant response to low media pH. Leaf tissue levels of Zn were elevated at low media pH and negatively correlated to plant growth and flowering characteristics, while imbalances in tissue levels of N, P, K, Ca, Mg, Fe, Mn, Cu and B appeared to be less important. Symptomatic plants grown in media with a pH from 5.0 to 5.8 had tissue levels of Zn ranging from 200 to 1200 ppm, and plants without symptoms in media with a higher pH had leaf tissue levels from 40 to 100 ppm Zn.

307 (PS VII)

#### ARTIFICIALLY DRYING EARLY HARVESTED PECANS AND ITS EFFECTS ON KERNEL TASTE

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Pecan growers are interested in harvesting pecans early because of better prices available early in the harvest season. Random samples from previously tagged nuts were taken each week for 7 weeks in 1985, and for 8 weeks in 1986. A 50-nut sample was weekly harvested for each of the following treatments: 1) fresh sample, 2) oven-dried for 24 hours at 29.4°C 3) oven-dried for 24 hours at 35°C, 4) oven-dried for 30 hours at 29.4°C, 5) oven-dried for 30 hours at 35°C, 6) dried at room temperature for 72 hours and 7) the control. At the start of the experiment, kernel moisture was about 14%. Some treatments brought kernel moisture below 5% the first week of the experiment. Drying nuts at room temperature reduced kernel moisture as effectively as other treatments. Kernel taste was evaluated after 3 months of cold storage. Judging by taste and moisture content, most treatments could have been harvested 4 weeks before normal harvest in 1985 and 5 weeks before in 1986. It seems that pecans can be harvested early and artificially dried, beginning around 4 weeks before normal harvest, without affecting quality.

308 (PS IV)

#### CONSUMER PREFERENCE FOR POLYETHYLENE CONTAINERS WHEN PURCHASING ORNAMENTAL TREES

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Product packaging influences consumer's purchase decisions, yet this influence is not defined for ornamental horticultural products. The objective of this study was to determine consumer preferences for three types of nursery plant containers: field ball and burlap, fabric bag, and polyethylene. Uniform Magnolia grandiflora and Photinia fraserii (1-2 m) grown in gro-bags were either containerized in black polyethylene pots, wrapped to simulate traditional ball and burlap, or kept in fabric bags. Seventy-four consumers from Montgomery, Ala., were asked to indicate their preferences. Most (48%) preferred the polyethylene container, followed by the fabric bag (27%), ball and burlap (19%). These data suggest that fabric bags have similar consumer appeal compared to ball and burlap. Plants in polyethylene containers likely appeared healthier and more vigorous because they held more soil, retained more moisture, and gave plants a better appearance.

309 (PS IX)

#### MANAGEMENT AND ECONOMICS OF SEQUENTIALLY GROWN VEGETABLES

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Cabbage, tomatoes and broccoli were grown sequentially at three levels of N fertilization with or without black polyethylene mulch in 1988 and 1989. Urea-NH<sub>4</sub>NO<sub>3</sub> at 136, 270 or 404 kg-ha<sup>-1</sup> was applied preplant or in triweekly increments

via drip irrigation. Economic returns were estimated from wholesale prices and production expenses. Crops receiving the medium and high N levels produced higher yields than those receiving the low N level. Nitrate concentrations in the soil corresponded to the levels applied and declined over the season. Yields of the first crop of the sequence (cabbage) were higher from preplant than from irrigation applied N. Yields of the second crop (tomatoes) were not affected by method of N application. Mulched plots produced higher yields than nonmulched plots. Soil nitrate concentrations were higher from mulched than from nonmulched plots but the rates of decline over the seasons were no different between mulched and nonmulched plots. Estimated net returns among all treatments varied from 20 to 30 and -9 to 5 thousand dollars per hectare in 1988 and 1989, respectively. Tomatoes contributed greatest to the estimated returns. Weather conditions and wholesale prices fluctuated widely between years.

310 (PS VII)

#### IMPROVEMENT OF PECAN BUD BREAK BY APPLICATION OF HYDROGEN CYANAMIDE.

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Pecan has an irregular bud break under mild climate areas, difficulting pollination and reducing yields, particularly in seasons when chilling accumulation is low and when only 50% of buds open. Hydrogen cyanamide (H<sub>2</sub>CN<sub>2</sub>) at 1, 2, 4% alone or with mineral oil (MO) at 2, 4% were evaluated for their effect on lateral bud opening of 'Wichita' pecans, spraying branches on January 25 or February 8. H<sub>2</sub>CN<sub>2</sub> and its mixtures with MO advances bud break 25 and 18 days as compared to control on first and second date application respectively; by March 20th shoots on applied branches had 8-14 cm length while control and MO treatments had only 2-3 cm.

Initial bud break was up to 85% on treated branches as compared to 60% of control; however and regularly, some shoots emerging from buds abscise thereafter. Remaining shoot number per branch was 4.8 with 4% H<sub>2</sub>CN<sub>2</sub> or the mixture 2% H<sub>2</sub>CN<sub>2</sub> + 2% MO on the first application date, and with 4% H<sub>2</sub>CN<sub>2</sub> + 2% MO on the second date, as compared to 2.5 shoots of control. A 12% bud injury occurred with 4% H<sub>2</sub>CN<sub>2</sub> on first date application and high rates of MO of second date.

311 (PS IV)

#### USAGE OF AND ATTITUDES TOWARD COMPUTERS FOR CUSTOMER-INTERACTIVE MARKETING IN GARDEN CENTERS

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A mail survey was conducted to determine attitudes held by garden center owners/managers about computers as customer-interactive marketing tools. The survey was sent to 220 garden centers in the 7-state North Central Region (IA, IL, IN, MI, MN, OH, WI), who were members of the Garden Centers of America. A response of 46% was received. Ownership of one or more computers was reported by 64% of respondents. Over 50% said they believe there is a place in garden centers for customer-interactive computer usage. Of those who did not agree that there is a place for point-of-sale computer usage in the garden center, the two most common objections were the impersonal nature of computers, and the cost. Survey results will contribute to development of perennial flower garden design software for use in point-of-sale marketing.

312 (PS IX)

#### EFFICACY OF SOLID WASTE COMPOST AS A PROPAGATION MEDIUM

S. D. Verkade\* and G. E. Fitzpatrick, University of Florida, Ft. Lauderdale, FL 33314

The availability of organic components of potting media is limited due to supply and shipping costs. Disposal of solid waste has also become a serious problem for many municipalities. The utilization of solid waste compost in agricultural production promises to be a solution for both concerns. The objective of this experiment was to determine the efficacy of solid waste compost from Miami, Dade County, Florida as a propagation medium for vegetative reproduction of ornamental and landscape plants.

Cuttings of Podocarpus macrophylla, Chrysobalanus icaro, and Impatiens spp. 1-13 cm long, treated with .2% NAA ppm IBA were rooted in media composed of sphagnum peatmoss: perlite (1:1) or Agrisoil (TM) solid waste compost: perlite (1:). Cutting rooted well in both media. Data included number of roots and root weight.

## EFFECTS OF FOLIAR CALCIUM SPRAYS ON ALUMINUM TOXICITY OF PEACH

Charles J. Graham\* and Gregorv L. Reighard, Department of Horticulture, Clemson University, Clemson, SC 29634-0375

Peaches are often grown on sandy, low pH soils which may predispose plants to aluminum (Al) toxicity. Previous research has shown that peach (*Prunus persica*, L. Batsch) is not tolerant to Al and toxicity may be associated with occurrence of peach tree short life syndrome. Current recommendations to control PTSL include soil calcium (Ca) applications to reduce soil acidity and Al availability. However, these applications often result in inconsistent responses. Objectives of this study were to determine if Ca would ameliorate the effects of Al toxicity and whether different Ca compounds would provide different responses.

Rootstock were grown in sand culture supplied with Hoagland's solution containing 16.7 mM aluminum. Trees received weekly foliar sprays containing 12.5 uM calcium and 0.1% Chevron X-77 as a spreading agent. Calcium compounds tested included calcium chloride, formate, lactate, nitrate, phosphate, and sulfate. Stem dry weights were significantly increased by Ca lactate and sulfate, leaf dry weight by Ca lactate, and Ca formate significantly increased leaf retention. Nutrient concentrations and interactions in leaves, stems, and roots will be discussed.

## 314 (PS IV)

## SIMPLIFIED PESTICIDE RATE CONVERSIONS USING A PROGRAMMABLE CALCULATOR

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Many pesticide labels contain rate recommendations in units that are not readily pertinent to container nursery production situations.

A program is presented, in the RPN programming language, for the conversion of pesticide rate terms from lb per ft to grams per container: f LBL A, RCL 2, ENTER, 1, 4, X, STO 5, RCL 3, ENTER, 2, ENTER, g X<sup>2</sup>, f, X, STO 4, RCL 1, 4, 5, 3, -, 9, X, STO 9, RCL 9, ENTER, RCL 9, ENTER, RCL 4, X, RCL 5, , g RTN.

Use of this program allows precise conversions of agricultural chemical application rates for container grown horticultural crops.

## 315 (PS IX)

## RESPONSE OF KEINTZLER NEW GUINEA IMPATIENS TO PINCHING

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Manually pinched plants of 18 cultivars of *Impatiens* hybrids (Keintzler New Guinea *impatiens*) were compared to control plants to determine the effect of apical meristem removal on flowering, growth and branching. Pinching delayed days to anthesis (first flower) of all cultivars, however, further delay in days to marketability (5 flowers open) was dependent upon cultivar. Plant area and fresh and dry weight were not affected by pinching plants of any cultivar. Cultivar influenced response to pinching treatments for plant height and plant width. Secondary branch number was increased by approximately 3 branches for all cultivars when plants were pinched. There were interactions between cultivar and treatment for primary, tertiary, and total branch number. Measured improvements in plant form determined two cultivars, Sylvine and Thecla, should be pinched. Chemically pinching these two cultivars with dikegulac at 780 mg-liter<sup>-1</sup> was comparable to manually pinching plants.

## 316 (PS VII)

## EFFECTS OF SHADE ON NET PHOTOSYNTHESIS, GROWTH AND YIELD OF STRAWBERRIES

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A greenhouse experiment was conducted to determine the effects of shade treatments (0, 30, 47 and 63%) on photosynthetic and growth responses of 'Redchief' strawberries. Net photosynthesis (Pn) measured on plants under shade decreased as % shade increased. Pn of plants grown under shade but measured under saturating light intensities decreased after 30% shade. Light saturation curves of leaves allowed to expand in full sun and then placed under shade indicated a decrease in the saturation rate and point under 63% shade. Leaves which expanded under shade had decreased saturation rates and points at all levels. Specific leaf weight and total plant dry weight decreased linearly as % shade increased.

A field study in which plants were either shaded in the fall or in the fall and spring demonstrated a decreasing trend in berry number

for plots which were shaded in the fall and spring. Berry number decreased in fall-shaded plants after 30% shade. In both cases, berry weight decreased with increasing shade.

## 317 (PS IV)

## RESEARCH TO PRODUCTION: LABORATORY SCALE-UP WITH MICROPROPAGATED ACER SACCHARINUM L.

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During the research phase, a system was developed to clonally micropropagate silver maple. Explant performance was best on DKW medium with 10 nM thidiazuron, and explants commonly developed 17 shoots after three months and over 60 shoots that could be rooted after four months in vitro. Plants were rooted (>90%) and acclimatized under intermittent mist and transplanted to an outdoor nursery bed. However, results were different during the production phase when 90 clones were propagated. Shoot proliferation rates were lower, differences in clonal response and worker efficiency were apparent, mass rooting under mist was inconsistent and acclimatization problems arose. The mean rooting was 46% under mist because of uneven coverage. Only 56% of rooted plantlets acclimatized which resulted in an overall efficiency of 26%. Partial solutions included root initiation in vitro, and use of fog for acclimatization.

## 318 (PS IX)

## PICLORAM-INDUCED ETHYLENE PRODUCTION BY BROOM SNAKEWEED

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Broom snakeweed [*Gutierrezia sarothrae* (Pursh) Britt. & Rusby] is a suffrutescent shrub that is a problem in rangeland production areas because it interferes with forage growth and is potentially dangerous to livestock. Picloram, an auxin-like herbicide, is used for broom snakeweed control. Picloram-induced ethylene production may be important to its efficacy, therefore, studies were conducted to characterize ethylene production and phytotoxicity. Picloram, applied as individual drops, induced a linear increase in ethylene production ( $r = 0.738^{***}$ ) between 0 and 72 hr after treatment. When plants were sprayed with 0.125, 0.25 and 0.50 lb ae/A, ethylene production increased linearly through 120 hr then leveled off and began to decrease for all three concentrations. The highest rate of ethylene production was induced by 0.25 lb ae/A followed by 0.50 and 0.125, respectively. Epinasty was evident 24 hr after treatment and chlorosis 3 to 4 days after treatment. Both were more severe with increasing picloram concentration. It appears that picloram-induced ethylene production is an important component in picloram activity.

## 320 (PS IV)

## TIMING OF CYTOKININ MEDIATED SHOOT INITIATION

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Several cytokinins at various concentrations were tested to determine which would stimulate the most synchronous shoot initiation. Kinetin was effective only at concentrations of 50 mg/L, while 2iP and zeatin were effective from 5 to 50 mg/L. BA at 10 mg/L produced the most synchronous and the greatest number of shoots. This treatment was used to determine at what point in development cytokinins stimulate shoots. Tissue was grown in the presence and absence of BA for various lengths of time. Application of BA for at least 10 days was required to initiate shoots. Explants were not affected by BA during the first 5 days of culture. Starving tissue for various periods caused a proportional lag in shoot production. Short pulses of BA at different developmental stages did not alter the cytokinin response. Vacuum infiltration of cytokinins prior to culture did not increase the BA response.

# EFFICACY OF THREE SPECIALTY OSMOCOTE FORMULATIONS (POINSETTIA, POTTED CHRYSANTHEMUM, AND ZONAL GERANIUM)

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Results from a preliminary study (growth parameters and foliar analyses) comparing a new specialty Osmocote formulation (12N-5.5P-12.4K) designed specifically for poinsettias with a standard Osmocote formulation (19N-2.6P-9.9K) revealed that the new formulation provided inadequate levels of nutrients at 1.0x and 1.5x the recommended rate. Average plant height (cm) for plants produced with 1.0x 12N-5.5P-12.4K, 1.5x 12N-5.5P-12.4K, 1.0x 19N-2.6P-9.9K was 33, 34, 37. Average plant diameter (cm) and foliar N content (%) was 42, 46, 53, and 2.8, 3.5, 4.1, respectively. Follow up studies (growth parameters and foliar analyses) comparing replacement shipments of three specialty Osmocote formulations (12N-5.5P-12.4K for poinsettias, 12N-4.4P-14.1K for potted chrysanthemums, and 13N-5.5P-9.1K for zonal geraniums) with Osmocote 19N-2.6P-9.9K and Peter's 20N-4.4P-16.6K injected at 200 mg N per liter of water at every irrigation showed all specialty formulations to be adequate sources of plant nutrients-comparable to the standard Osmocote. Average chrysanthemum height (cm) for plants produced with 1.0x 12N-5.5P-12.4K, 1.5x 12N-5.5P-12.4K, 1.0x 19N-2.6P-9.9K, Peter's 20N-4.4P-16.6K was 30, 30, 30, 29. Average chrysanthemum diameter (cm) and foliar N content (%) was 51, 50, 49, 50, and 4.5, 4.8, 4.4, 5.2, respectively.

## 322 (PS VII)

# ROOT DISTRIBUTION OF TRICKLE AND FLOOD-IRRIGATED GRAPEFRUIT

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Root distribution of trickle- and flood-irrigated 4-year-old 'Ray Red' grapefruit (*Citrus paradisi* Macf.) trees on sour orange (*C. aurantium* L.) rootstock was studied utilizing a trench method. Irrigation treatments were: flooding at 50% soil water depletion, trickle irrigation (2 drippers per tree) at 0.5 Class A Pan evaporation or at 0.02 MPa soil tension. Two trees from each treatment were studied. Five 2.5 m deep trenches positioned perpendicular or parallel to the tree row at 0.6, 2.1, or 4.3 m from the tree trunks were dug per tree. After washing off a 0.5 cm thick layer of soil from the trench wall, 0.5 cm long root sections were marked on a transparent plastic film attached to the wall. Many roots of trickle-irrigated trees grew past the trickle wetted zone and extended beyond 2.1 but not 4.3 m of the trunk. However, the roots of flood-irrigated trees were present at all distances from the trunk. From 26 to 51% of the roots of trickle-irrigated trees were found 90-230 cm deep, despite the clayey texture of the top 1 m of soil which was underlaid by a sandy clay loam. The root systems of flood-irrigated trees were shallower and in most cases confined to the top 90 cm soil layer.

## 323 (PS IV)

# TISSUE CULTURE STUDIES ON *Stevia rebaudiana* AS A SOURCE OF NEW SWEETENER CROP

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*Stevia rebaudiana* Bert.) leaves produce stevioside and rebaudioside that can be used as a natural source of low-calorie sweetener which is heat-stable. Because of low fertility, this plant is often vegetatively propagated for field production. This study was conducted to optimize tissue culture procedures for propagating selected clones and explore the feasibility of producing the sweetener compounds by callus cultures. Shoot proliferation was best in Murashige and Skoog (MS) medium supplemented with 0.1 mg/l naphthaleneacetic acid (NAA) Plus 10 mg/l kinetin. Kinetin as a cytokinin source was better than benzyladenine (BA) especially when NAA was present. Callus production from leaf disc cultures was most prolific when a combination of 0.1 mg/l NAA and 3 mg/l BA was used in MS medium. The relative sweetener contents of callus cultures are currently being-analyzed.

## 324 (PS IX)

# RELATIONSHIP OF IRON AND MANGANESE AVAILABILITY IN PEAT-BASED MEDIA TO THE OCCURRENCE OF A SPECIFIC PHYSIOLOGICAL DISORDER IN *TAGETES ERECTA*

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A specific physiological disorder of the recently matured leaves of *Tagetes erecta* has been demonstrated to be associated with high levels of iron and manganese in affected tissues. In previous work by the authors, the

disorder was inducible and increased in severity with increasing levels of iron DTPA supplied to plants grown in peat-based media, but was much less severe when iron DTPA treatments were applied to plants grown hydroponically. At low concentrations of iron DTPA in solution, the occurrence of the disorder was more closely correlated with increased levels of manganese in leaf tissue than iron. Objectives of this study were to determine the effects of iron chelate (DTPA) on occurrence of the disorder and the availability of iron and manganese in the media in the absence of added manganese. Iron DTPA (1, 5, 15, and 20 ppm) was supplied to two cultivars of *Tagetes erecta*, 'Voyager' and 'First Lady', grown in a commercial peat-based media product under controlled environmental conditions. Concentrations of iron and manganese in leachate samples taken weekly, and in symptom and non-symptom tissue at harvest, and the progression of the symptoms in leaf tissue over time, will be discussed.

## 325 (PS VII)

# BLOOM AND RIPENING OF *RIBES* IN CORVALLIS, OR

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In commercial growing regions the bloom period for currants and gooseberries is critical to crop development because of potentially damaging spring frosts. Breeding programs in northern latitudes include selection for frost avoidance mechanisms such as late blooming tendencies. Corvallis climate is milder than *Ribes* production regions, with the average winter minimum temperature about 10C and the coldest recorded April temperature of -5C in 1926. The last spring frost occurs by April 14 on average. About 30 cultivars and species selections of currants and about that same number of gooseberries were evaluated for blooming and fruiting at the National Clonal Germplasm Repository. Dates of first bloom, last bloom, first ripening, and last ripening during 1987 through 1989 were collected. The longest ripening period, 93 days, occurred in 1989 on a selection of *R. burejense* F. Schmidt. The shortest ripening period in 1989 was 70 days, occurring in many black currant cultivars including Black September, Crusader, Coronet, and Invigo. These same cultivars required a range from 62 to 66 days to ripen in 1987. For the years examined thus far, the earliest ripening dates occurred in 1987, starting as early as Julian date 150; the latest ripening date (192, Julian) occurred in 1988. Data from 1990 will be presented. The climate in the Pacific Northwest is favorable for the production of currants and gooseberries.

## 326 (PS IV)

# INFLUENCE OF A SOIL-INCORPORATED HYDROGEL ON IRRIGATION REQUIREMENTS AND QUALITY OF TRANSPLANTED SOD

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The purpose of this study was to evaluate the effectiveness of soil-incorporated hydrogel to reduce irrigation requirements of transplanted Kentucky bluegrass (*Poa pratensis*) sod. The treatments included an untilled control, tilled soil, and tilled soil with incorporated hydrogel. Initial irrigation treatment were made daily, at various percentages of potential evapotranspiration (PET), to determine irrigation requirements of newly transplanted sod. Other irrigation treatments were later imposed on transplanted sod which had been established at 100% of PET, to determine irrigation requirements of established sod. Turf quality was measured weekly, and sod transplant rooting strength was also measured.

## 327 (PS IX)

# NOTCHING TECHNIQUES TO INCREASE BRANCHING OF YOUNG APPLE TREES

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A series of experiments were initiated to evaluate the influence of notching on improving lateral branching of young apple trees. Buds on 2-year-old wood of 'Redspur' Delicious/MM.111 were notched at 2-week intervals from 6 weeks before bloom to 2 weeks after. Notching increased lateral branching cubically with the greatest response occurring when notching was done 2 to 4 weeks before bloom. Bud break occurred equally well and shoots grew comparably when 'Redcort'/M.7 were notched at the tip, middle, or base. Bud break and shoot growth from unnotched buds was greatest at the tip, intermediate in the middle and least at the base. Limbs of 'Spygold'/M.7 were spread to a 45 degree angle then one bud from each 1-year-old shoot was notched at either the top, side or on the bottom of the shoot. Notching increased lateral branching from all bud positions, but the greatest response was from buds notched at the top and least from those located at the bottom of a branch. Buds of 'Marshall McIntosh' were notched on either 1 or 2-year-old wood. Notching increased lateral branching more on 2-year than on 1-year old wood.

328 (PS VII)  
EFFECTS OF FALL ETHEPHON AND GIBBERELIC ACID  
APPLICATIONS ON BLOOM DELAY, FLOWERING, AND FRUITING  
OF PLUM

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The influence of fall applications of ethephon and gibberellic acid to produce bloom delay in 'Wade' plum were carried out in 1987-89. Single saturation applications of ethephon at either 125 and 250 mg-liter<sup>-1</sup> with 50 mg-liter<sup>-1</sup> gibberellic acid (GA) at first sign of leaf fall in October of 1987 produced bloom delay of 6-17 days the following spring. No difference in bloom delay was seen between the two treatments. Gummosis and death of some lateral shoots were observed in both treatments but was more severe at the higher ethephon concentration. There was no adverse effect on flower bud opening in either treatment. In 1988 untreated trees suffered 100% fruit loss because of frost injury while both treatments allowed for excellent yields as a result of frost avoidance. In the fall-spring of 1988-89 the experiment was repeated on the same trees; a 5-8 day delay in bloom was observed in both treatments but a late freeze destroyed all fruit on both treated and untreated trees.

329 (PS IV)  
FRUIT AND VEGETABLE INTAKES BY INDIVIDUALS IN THE 1987-88  
NATIONWIDE FOOD CONSUMPTION SURVEY

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Using data from the United States Department of Agriculture (USDA) Nationwide, Food Consumption Survey (NFCS) conducted from April 1987 through Summer 1988, 1-day intakes of fruits and vegetables by 10, 138 individuals are described. Mean intakes and percentages of individuals using total fruits, citrus fruits and juices, apples, bananas, other fruits and mixtures mainly fruit, noncitrus juices and nectars, total vegetables, white potatoes, tomatoes, dark-green and deep-yellow vegetables, and other vegetables are presented. Fruit and vegetable consumption patterns by age and sex (18 groups), by race (black and white), by region (Northeast, Midwest, South, and West), and by income level as a percentage of poverty (under 131%, 131-300%, and over 300%) are illustrated.

330 (PS IX)  
SHOOT REMOVAL AFFECTS *ALSTROEMERIA* DEVELOPMENT  
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of Maryland College Park, MD 20742

Thinning of *Alstroemeria* 'Regina' at 0, 30, 60, or 90% did not result in induction of cyclic variation in shoot length. Thinning caused an overall decrease in stem length and final fresh weight of storage roots (SR). Number of nodes on generative shoots did not change due to thinning treatment but varied over time. Thinning by 90% reduced yield, delayed harvest and increased flower quality. In the second year, plants were rethinned and grown with supplemental HPS irradiance of either 25 or 125  $\mu\text{mol m}^{-2}\text{sec}^{-1}$ . Weekly production diminished with increased thinning, and was amplified by increased total fluence. In a second experiment, thinning resulted in decreased shoot, rhizome and SR growth in plants sampled before and after flowering. Rhizome index increased with increased thinning, indicating a relatively smaller impact of thinning on rhizome growth compared to SR and shoot growth. The carbohydrate composition of SR tissue was unchanged by treatment. Thinning resulted in decreased SR production and decreased fresh weight per SR between thinning treatments. Change in total amount of carbohydrate reserves in the SR is therefore due to change in number & size of the SR.

331 (PS VII)  
APPLE FRUIT CUTICULAR WAX INFLUENCE ON FLYSPECK, SOOTY BLOTCH,  
AND RUSSETING

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Fruit from six cultivars of mature apple trees were evaluated for cuticular wax characteristics. Incidence of flyspeck, sooty blotch and russet was compared to the wax component of the cuticle. Three cultivars of Golden Delicious: Sundale Spur, Pure Gold, and Lys Golden; and three

cultivars of Red Delicious: Starkspur Supreme, Oregon I, and Starkrimson, were examined.

Incidence of flyspeck on Golden Delicious apples was negatively correlated to cuticular wax per unit area. Sooty blotch appearance was greater on Golden Delicious fruit as compared to Red Delicious. Incidence of sooty blotch was positively correlated to cuticular wax weight per unit area among the cultivars of Red Delicious. Russetting was negatively correlated to wax weight per unit area for the Red Delicious cultivars. Wax compositional analysis will also be discussed.

332 (PS IV)  
USING LOTUS 123 TO INTERCONVERT ILLUMINANCE,  
IRRADIANCE, AND PHOTON FLUX DENSITY VALUES  
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Because ASHS has adopted in their editorial policies the use of Systeme International (SI) units, it has become necessary to report light measurements in units other than footcandles. Since measurements using a radiometer can be tedious, tables providing values for different sources of light are often used to approximate required units. Using the tables provided by Thimijan and Heins [HortScience 18(6): 818-822], a Lotus 123 worksheet program was designed to interconvert photometric, radiometric, and quantum light units of measure. The worksheet is menu driven and can handle straight conversions or mixed conversions by entering requested information. Setup of the worksheet and instructions in its use will be provided at the meeting.

333 (PS IX)  
FIELD PERFORMANCE OF BIO-PRIMING FOR PROTECTION OF sh2 SWEET  
CORN FROM PREEMERGENCE DAMPING-OFF CAUSED BY *PYTHIUM* ULTIMUM.  
Nancy W. Callan\*, Don E. Mathre, and James B. Miller,  
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Shrunken-2 supersweet (sh2) sweet corn is susceptible to preemergence damping-off caused by *Pythium ultimum*, especially when planted into cold soil. Bio-priming, a seed treatment which combines the establishment of a bioprotectant on the seed with preplant seed hydration, was developed to protect seeds from damping-off.

In a series of field experiments conducted in Montana's Bitterroot and Gallatin Valleys, bio-priming or seed bacterization with *Pseudomonas fluorescens* AB254 protected sweet corn from *P. ultimum* damping-off. Bio-priming corn seed with *P. fluorescens* AB254 was comparable to treatment with the fungicide metalaxyl in increasing seedling emergence. Seedlings from bio-primed seeds emerged from the soil more rapidly than from nontreated seeds and were larger at three weeks postplanting. Seeds of sh2 and sugary enhancer (se) sweet corn, as well as that of several sh2 cultivars, were protected from damping-off by bio-priming.

334 (PS VII)  
APPLE ROOTSTOCK INFLUENCE ON YIELD, YIELD EFFICIENCY, AND  
TRUNK GROWTH AFTER TWENTY-FIVE YEARS  
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The influence of 9 rootstock on growth and production of 'Goldspur' (GS) and 'Wellspur Delicious' (WS), and of 3 rootstock on growth and production of 'Red King Delicious' (RK) and 'Golden Delicious' (GD) apple was evaluated. The spur-type 'Delicious' (WS) produced more fruit per tree than the non-spur (RK) strain with Mailing (M) 7 and Mailing-Merton (MM) 106 but not with M 26. GD produced more fruit per tree than GS on M 7 and M 26 but not MM 106. Yield efficiencies were usually superior with spurred strains. Efficiency of RK was markedly inferior to GD and WS. Comparing cumulative yields among 9 stocks within spurred strains showed that highest yields were with MM 106 roots. Clonal stocks were more efficient than seedling. The least size-controlling stocks (seedling, MM 104, MM 109, and M 25) tended to be less efficient than M 2, M 7, M 26, MM 106, or MM 111, but the trends throughout the experiment were not consistent. Seedling, MM 104 and MM 109 had the largest trees with spurred tops, and M 26 the smallest.

### 335 (PS IV) DEVELOPMENT OF THE URBAN FORESTRY NOTEBOOK

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Decisions regarding the selection and care of trees on public lands often are delegated to public employees with limited knowledge of tree care. To provide a technical resource for the municipal employee, the Urban Forestry Notebook was developed through sponsorship by Puget Power (a major Pacific Northwest utility company), Washington State Department of Natural Resources, and the Center. The unique focus of this Notebook provided the municipal employee with information on the selection and care of 65 of the most important urban trees. It also can be used as a model by other communities who wish to improve the care of their urban trees by providing an informational resource for the public employee.

### 336 (PS IX) VEGETATIVE GROWTH AND FLOWERING OF DENDRANTHEMA GRANDIFLORA TZVELEV. 'SPEARS' IN RESPONSE TO INCORPORATED APPLICATIONS OF CONTROLLED-RELEASE FERTILIZERS

Allen D. Owings\*, Department of Horticulture, Mississippi State University, Mississippi State, MS 39762, Warren A. Meadows and Donald L. Fuller, Department of Horticulture, Louisiana State University, Baton Rouge, LA 70803, and Melinda R. Stewart, Department of Horticulture and Forestry, University of Arkansas, Fayetteville, AR 72701

Recent studies at Louisiana State University evaluated incorporated rates (0.72, 1.08, and 1.44 kg N/m<sup>2</sup>) of controlled-release fertilizers (Chrysanthemum Mix 12N-4.4P-14.1K, Osmocote 14N-6.1P-11.6K, and Nutricote Type 70 14N-6.1P-11.6K) on vegetative growth and flowering of 'Spears' potted chrysanthemums. Data collected included fresh and dry weight, height, width, flower size, flower number, days to first flower color, and days to flower finish.

Flower characteristics were not greatly affected by fertilizer or application rate. Dry weight increased with an increase in application rate from 0.72 kg N/m<sup>2</sup> to 1.44 kg N/m<sup>2</sup>.

### 337 (PS VII) AUTUMN ETHREL SPRAYS ON PEACHES; OBSERVATIONS OF WINTER HARDINESS AND BLOOM

Keith Patterson\*, Curt R. Rom, Robert Bourne, and John C. Clark, Dept. of Horticulture and Forestry, Univ. of Arkansas, Fayetteville, AR 72701.

Ethrel sprays were applied at 50 or 100 ppm at approximately 40%, 70% leaf fall (10/16/89 or 10/24/89, respectively) or at both times on 'Redhaven' and 'Allgold' peaches. Bud hardiness was determined biweekly by differential thermal analysis (DTA). Stage and percentage of bloom open during the bloom period were subjectively estimated.

Spraying trees with 100ppm Ethrel at 50% leaf fall significantly increased bud hardiness at mid-winter compared to other treatments. After a mid-winter freeze (-21.7 C on 12/21/89), there was no significant difference between % bud survival of any treatments. But, trees treated with 50 or 100ppm Ethrel had 10-20% better bud survival than other treatments. Buds of the 2 cultivars had statistically similar hardiness although DTA analysis indicated that Redhaven had a .5-.8 C lower freezing point than Allgold in mid winter. This trend was reversed close to bloom with Allgold having .7 C lower freezing point than Redhaven. The time of full bloom was significantly delayed by treating trees with 100ppm at 40% leaf fall or 50ppm at both 40 and 70% leaf fall the previous autumn.

### 338 (PS IV) A HYPERCARD APPLICATION FOR THE SELECTION OF SOUTHERN LANDSCAPE PLANTS

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Designing a landscape involves the selection of plants with certain characteristics such as height, color, hardiness zone, bloom time, etc. A Hypercard stack, which is a specific type of software application for Macintosh computers, was developed to aid landscapers in the location of plants with the desired characteristics. This Hypercard stack, called the "Plant Stack", is based on the book, *Identification Selection and Use of Southern Plants for Landscape Design*, by Dr. Neil Odenwald and James Turner. The stack is also useful as an educational tool; for example, it can be used as a set of flash cards. Use of the software for selecting southern plants will be discussed as will use of the same software as an educational tool.

### 339 (Ps Ix) INFLUENCE OF TRICHODERMA ON THE GROWTH OF BEDDING PLANTS

GyeSoon Jeong\*, John M. Brown and Byoung Ryong Jeong, Department of Horticulture, University of Missouri, Columbia, MO 65211

Trichoderma spp. are currently being investigated for biological control of soil-borne pathogens and their potential to enhance plant growth and development. The influence of *T. harzianum* and *T. hamatum* on growth of 7 bedding plant species was investigated. Trichoderma formulated in peat moss and wheat bran, was mixed into germination and growing media at  $1 \times 10^6$  cfu per gram of medium. Seeds were germinated in plugs and later grown in cellpacks containing a treated and non-treated medium until market stage. Plants were evaluated by measuring height, fresh and dry weight, and number and timing of flowering. Growth enhancement was found in marigold (14.8% dw), petunia (15.5% dw) and tomato (38.2% dw), however, no significant differences were seen in celosia, impatiens, salvia and vinca. Results suggest that growth enhancement by Trichoderma is species dependent and that Trichoderma applied in the plug mix remains-effective through marketing stage.

### 340 (PS VII) SHOOT GROWTH AND DEVELOPMENT OF 'STARKSPUR SUPREME DELICIOUS' VARIES WITH ROOTSTOCK.

Curt R. Rom, Dept. of Horticulture and Forestry, Univ. of Arkansas, Fayetteville, AR 72701

Shoot growth 'Starkspur Supreme Delicious' on 10 different rootstock was measured on 3-, 4- and 6-year-old trees at weekly intervals from budbreak until terminal bud formation. Spur density, spur development, and extension shoot leaf area development were measured in September. Growth rate was analyzed by regression against chronological time and accumulated growing degree days using linear and nonlinear statistics.

Rootstock affected shoot length, leaf number, leaf area, leaf size, leaf dry weight/leaf area and internode length. Trees on M.4, M.7 EMLA, P-1 and seedling had the longest shoots and highest shoot growth rate. Trees on P16 had least leaves and leaf area per shoot and smallest shoot leaves. Leaf dry wt/area were negatively correlated to leaf size. Typically, trees with shortest shoot length and smallest internode length had greatest spur density. Rootstock affected both rate and duration of shoot growth. Shoots on trees with P22 and P2 rootstocks grew for the shortest duration while trees on M.4 and M.7 EMLA grew for the longest period.

### 341 (PS IV) A CLASSROOM LABORATORY EXERCISE TO DEMONSTRATE SEED PRIMING

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Plant propagation instructors are challenged to develop laboratory exercises that demonstrate the theoretical aspects of seed germination. Seed priming or osmoconditioning is a relatively new technique that has been shown to improve seed performance in horticultural crops. An easily constructed seed priming system was designed using a pair of 2-liter glass jars, 2 aquarium pumps and air tubing. Eight sets of 40 seeds were each wrapped in coffee filters and laced in aerated treatment solutions consisting of 50 mmole K<sub>2</sub>HPO<sub>4</sub> or an untreated control of distilled water. All seeds were treated or 0, 1, 3 or 5 days. Upon completion, seeds were rinsed, dried and placed into petri dishes containing moist filter paper to observe germination. A good test species for this exercise is *Vinca rosea* which typically has a poor germination percentage and rate. Seeds primed for 3 and 5 days significantly enhanced both germination percentage and rate in *Vinca*.

### 342 (PS IX) AN INTEGRATED PEST MANAGEMENT APPROACH TO CONTROL OF WESTERN FLOWER THRIPS (FRANKLINIELLA OCCIDENTALIS).

Marsha A. Bower\*, L. Michele Quinn, and John M. Brown, Department of Horticulture, University of Missouri, Columbia, MO 65211

Experiments were conducted to investigate the feasibility of biological control measures to control Western Flower Thrips. Thrips population and preferred trap color were examined using sticky trap tapes in 5 fluorescent colors, orange, yellow, green, blue and pink. Results indicated that pink is more effective in attracting thrips than the traditional yellow or the newly acclaimed blue sticky traps on the market now. Studies were also conducted to determine if the entomogenous nematode (*Steinernema feltiae*) could invade and parasitize Western Flower Thrips, and which stage of the thrips life cycle was

most susceptible to parasitization. Thrips were dissected and checked for nematode invasion at 24, 48 and 72 hours after inoculation. *S. felitiae* was found to invade the body cavity after 24 hours in the larval stage of Western Flower Thrips resulting in death.

### 343 (PS VII)

#### REGENERATION OF CITRUS VIA SHOOT APECIES

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Viral damage is a major problem in citrus. As most citrus are asexually propagated, it is necessary to have an alternative way of regenerating virus-free plants from infected plants. Shoot apices are the most suitable explant material for this purpose because that part of the plant is virus-free. Fifty sour orange shoot tips and 22 Swingle shoot tips, 1 mm - 1.5 mm long, were excised from in vitro germinated seedlings and cultured on semi-solid Murashige and Skoog medium, without growth regulators, containing 0.2 % Gelrite. After 8-10 weeks, shoots and leaves developed in 68% of the sour orange explants, and in 77% of the Swingle explants. Some explants produced roots, after 11-12 weeks, and could be removed from culture and established in soil medium.

### 344 (PS IV)

#### RELEASE OF A NEW GARDEN CENTER MANAGEMENT MANUAL

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Few good texts for use in teaching a garden center management course are currently in print. But a wealth of excellent information exists in the form of trade journal articles and business management publications. The second edition of The Garden Center Management Manual combines pertinent articles into 21 categories (chapters). Each chapter begins with a "fill-in-the-blank" summary designed as a guide for note-taking. A teacher's edition is available with the completed summaries. The articles in each chapter appeared in trade journals or other publications between 1985 and 1990. This text can serve as the basis for a garden center management course or as a reference for garden center managers.

### 345 (PS IX)

#### INSECTICIDE RESISTANCE IN WESTERN FLOWER THRIPS IN GREENHOUSE CROP PRODUCTION,

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Control failures of many insecticides used against the western flower thrips (WFT), *Frankliniella occidentalis* (Pergande), have been reported from several locations by greenhouse operators. To document resistance, thrips were bioassayed by placing them in vials coated with doses of diazinon, methomyl, bendiocarb, dimethoate, azinphosmethyl and cypermethrin at (100, 50, 10, 5, 1, 0.5 and 0.1 g/vial). Adult female WFT were collected from a colony exhibiting control failures using organophosphate, carbamate and pyrethroid insecticides. A colony showing no resistance was used as a control. The LC<sub>50</sub>'s of the resistant and susceptible strains were diazinon 49.3 and 4.6 g/vial, cypermethrin no mortality and 3.7 g/vial, and azinphosmethyl 20.2 and 2.1 g/vial respectively. Results show resistance is present as well as cross resistance to diazinon and cypermethrin because the resistant population was never exposed to these compounds.

### 346 (PS VII)

#### CHARACTERIZATION OF GROWTH AND METAL-BINDING CONSTITUENTS OF TWO CITRUS CELL CULTURE LINES

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Citrus blight is an extremely complex decline disorder of unknown etiology, Zinc accumulates in the phloem of the tree 40-50 cm above the bud union 1-3 years prior to visible symptoms of blight

(foliage wilt and twig dieback). This is accompanied by Zn deficits in the leaves. A Zn-binding peptide (ZBP) purified from citrus phloem tissue accounts for a symptomatic redistribution of Zn from the canopy to the trunk phloem. ZBP is found in blight and healthy trees and is therefore a normal component of cellular metabolism. To further understand ZBP's role in metabolism two citrus cell culture lines which were selected based on their susceptibility to blight have been characterized as to their growth under Zn treatments as well as Cu and Cd. In addition, their complement of metal-binding constituents is being determined.

### 347 (PS IV)

#### SCREENING OF SOMACLONAL VARIANTS IN VITRO TO PRODUCE INSECT RESISTANT PLANTS

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Callus cultures of *Torenia fournieri* 'Compacta Blue' were initiated on a modified Murashige and Skoog salt medium (MS) with 2.26 uM 2,4-dichloro-phenoxy acetic acid. Shoots were regenerated from these cultures using the MS medium amended with 2.46 uM 3-indolebutyric acid and 8.88 uM 6-benzylamino-purine. These shoots were subjected to *Tetranychus urticae* Koch (twospotted spidermite) and *Trialeurodes vaporariorum* (Westwood) (greenhouse whitefly) in vitro. Pests were allowed to feed until such time that the pest population started to decrease due to lack of food. Remaining shoot tissue was placed on MS medium amended with 2.28 uM zeatin to induce shoot formation. Shoots were acclimated to greenhouse conditions and evaluated for resistance to the pest to which they were subjected in vitro. Highly significant differences in pest numbers were found in somaclones when compared to control plants. A wide range of variability was observed within the somaclonal population.

### 348 (PS IX)

#### EFFECT OF IRRIGATION TREATMENTS AND TIME OF FOLIAR-APPLIED UREA ON YIELD OF NAVEL ORANGE (*CITRUS SINENSIS* L. OSBECK)

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This study investigated the effect of irrigation treatments and time of foliar applications of low-biuret urea on yield of 30-yr-old navel orange trees grown under optimal N fertilization. The experiment was carried out at the Agricultural Experiment Station of the University of California, Riverside, using split plot design with 12 replications. The two irrigation treatments were the mainplots and the urea applications were the subplots. Irrigation was withheld from one set of trees from October to March, the other set was irrigated according to commercial practice. Foliar-urea (0.17 kg/tree) was applied in November, December, January, or February.

The results of the first year showed no significant differences between irrigation treatments with regard to total fruit weight or total number of fruit per tree. All trees receiving urea had significantly higher fruit weight and fruit number per tree than the control trees. The specific time of urea application had no significant effect.

With respect to fruit size distribution, the irrigated treatment resulted in a significantly higher number of fruit of size 7.0-8.0 cm (box sizes 88-72). Generally, the non-irrigated trees had more fruit of size 6.0 cm or less. No interaction between irrigation treatments and foliar urea sprays was observed.

### 349 (PS VII)

#### EFFECT OF CONTAINER SIZE AND PRUNING ON GROWTH AND DEVELOPMENT OF DWARFING MANGO ROOTSTOCKS. A. Cedeño-Maldonado\* and E. Méndez, Dept. of Horticulture, Univ. of Puerto Rico, Mayaguez, P.R. 00708

Control of tree size is an important consideration in developing commercial mango orchards. The use of dwarfing rootstock is one of the methods available for controlling tree size. The development of techniques for increasing the effect of dwarfing rootstock is the objective of the present research. Container size treatments consisted of planting seedlings of different rootstock in containers of 1 to 8 L in size. Pruning treatments consisted of removing the shoot, root or shoot-root (combined) tips of young seedlings previous to planting. Most significant changes were produced by using the smallest containers and combined pruning. Most significant fresh and dry weight reductions were obtained in the smallest containers. Combined pruning produced a significant increase in fresh weight-of both roots and shoots but no significant changes in dry weight. Plant height was not significantly affected but bark thickness was significantly reduced by decreasing container size. Eldon a monoembryonic variety was significantly bigger than polyembryonic varieties.



## 350 (PS IV)

## MANUAL FOR CERTIFIED NURSERY AND LANDSCAPE PROFESSIONALS

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A manual for certified nursery and landscape professionals has been developed by the University of Minnesota Extension Service in conjunction with the Minnesota Nursery and Landscape Association (MNLA). The purpose of the certification manual is to facilitate the improvement of basic skills and knowledge of nursery and landscape professionals, to further the education and training of competent nursery and landscape professionals, and to serve as a training and reference manual for most levels of nursery and landscape culture and management. The manual consists of thirty-four chapters covering all aspects of woody plant biology and culture; abiotic and biotic plant stress; landscape design; installation and maintenance; plant marketing, merchandising and sales; and laws, regulations and safety concerns for nursery, landscape and garden center personnel. A concise glossary, the American Standard For Nursery Stock, and an illustrated nursery catalog are also included in the manual. The manual is an important part of the MNLA Certification Program whose purpose is to improve the skills, knowledge and, expertise of nursery and landscape professionals. The Certification Program also strives for faster recognition and promotion of professionalism within the industry and to the general public.

## 351 (PS IX)

## HOME USE OF LAWN AND GARDEN CHEMICALS AND THE POTENTIAL FOR GROUND WATER CONTAMINATION

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Public concern over the impacts of pesticides and fertilizers on ground water quality has been increasing. Health impacts from ingestion of these chemicals in ground water vary considerably. Recent estimates of the volume of pesticides used in the U.S. indicate that home and garden uses account for about six to eight percent of total pesticides used. To obtain information on types and application rates of home garden chemical use, a telephone survey of Virginia homeowners was undertaken in the summer of 1988. Information was obtained on: 1) size of respondents' lawns and gardens; 2) use of a professional service to manage the lawn or garden; 3) what chemicals were applied and frequency; 4) sources of information used in making chemical use decisions; 5) use of product label instructions and difficulty in interpreting instructions; and 6) perceived threat to water quality, human health, or ground water from properly used home and garden chemicals.

## 352 (PS VII)

## EFFECTS OF CHRONIC SHADE AND FOLIAR NUTRIENT SPRAYS ON APPLE SPUR VIGOR AND PERFORMANCE

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Eleven year-old Empire/M.7 apple trees were shaded continuously for 4 years with half-tree shading cages. Shading reduced primary spur leaf duration, bourse shoot leaf area, specific leaf weight, spur diameter and bud diameter. Over the four years, shaded spurs continued to increase in length but spur diameter increased very little resulting in long and brittle spurs. However, shaded spurs continued to flower and set fruit. Leaf area development was similar inside and outside the cages at one week after bloom but by 2 weeks after bloom, spurs inside the cages had significantly lower leaf area. Shading reduced fruit set, fruit size, fruit color, fruit soluble solids and fruit dry matter. Fruit growth rate was reduced by shading early in the season but was no different than the unshaded controls by 4 weeks after full bloom.

In an attempt to reverse the negative effects of shading on spur vigor, foliar urea, zinc-EDTA and solubor were sprayed 3 times during the early growing season each year. Rather than increasing spur leaf area, foliar nutrient sprays significantly reduced bourse shoot leaf area and did not increase the duration of primary spur leaves. Although foliar nutrients reduced total spur leaf area, they improved fruit size, color and soluble solids slightly.

## 353 (PS IV)

## NEW SPECIALTY CROPS FOR HOME AND MARKET GARDENS

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The primary goal of this project is to introduce various citizenry groups within Wisconsin to new and potentially profitable alternative crops and production systems, and to acquaint them with crops and ornamental which may be common in Europe and Asia but which have not been extensively

grown in our region. Approximately 50 new cultivars of gourmet vegetables, edible flowers, everlasting flowers, fresh cut flowers, and ornamental grasses were field tested 3 years for their adaptability for home and market gardens in Wisconsin. Cultivars were chosen for their unique flavor, color, shape, or texture. Greenhouse grown plants were transplanted onto black plastic mulch, with an annual ryegrass living mulch planted between crop rows. Aside from carbaryl and *Bacillus thuringiensis* used for cole crop insect control, no chemical pesticides or herbicides were used. Data taken includes notes on production, climate adaptability, disease and insect stress, maturation date, color, taste, and texture. Regional interest has been widespread from various groups including growers for gourmet restaurants, farmers market producers, garden clubs, youth organizations, and urban gardeners..

## 354 (PS IX)

## COMPARISON OF LOW VOLUME DRIP AND SUBIRRIGATION SYSTEMS.

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Low volume drip (2 l/h) was compared with 2 subirrigation ('trough' and 'ebb and flo') systems for production of poinsettias and chrysanthemums in 15 cm diameter (1.6 l) 'azalea' pots. Irrigation frequency as well as fertilizer rates were the same for all systems. The drip system received 280 ml per watering.

Two plantings of poinsettias (fall) as well as two plantings of chrysanthemums (spring and summer) showed no differences in plant growth between the drip and the subirrigation systems. Water uptake by the medium was similar for all irrigation systems, but water and fertilizer application was 70% higher for the drip system. Nutrients, measured at 4 depths within the pot at monthly intervals, increased with time and was markedly more concentrated in the top layer, regardless of the irrigation system.

## 355 (PS VII)

EVALUATION OF STRAWBERRY (*FRAGARIA SP.*) SEEDLINGS FOR DROUGHT AND SALT TOLERANCE BY *IN VITRO* INDUCED STRESSES.

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Crosses and self's were made among *Fragaria* × *ananassa* Duchn. cv. 'Douglas' and 'Fern' and *Fragaria chiloensis* (L.) Duchn. Seeds were surface sterilized, germinated and then grown on MS media (no vitamins, sucrose or hormones) with NaCl concentrations of 0 to 0.5% or 0.5% KCl. Polyethylene glycol (PEG), of corresponding water potentials, was used to induce drought stresses. Whole plant dry weights were evaluated after 50 days. Differences in salt tolerance were associated with genotype; progeny involving crosses with *F. chiloensis* showed greater salt tolerance. Increases in concentration of PEG caused decreased growth. The use of salt containing media may be used to evaluate strawberry seedlings for salt tolerance and, similarly, PEG may be used to evaluate for drought stress *in vitro*.

## 356 (PS IV)

## HORTICULTURE INTERACTIVE VIDEO PROGRAMS IN VIRGINIA

Carol Ness, Leslye Bloom, P. Diane Relf\*, and Mary Miller, Ext. Interactive Design, Ext. Interactive Design, Dept. of Hort., and Ext. Interactive Design, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0530.

Horticulture information is being placed at the fingertips of Virginia citizens through the use of Public Information Interactive Video Systems. A personal computer (with a touch-screen monitor) and laserdisc player work together to offer a multi-media delivery system. The user moves through programs by simply touching the screen to browse, skip ahead, back up, look up specific information, and print out needed information. A program on household plants contains photographs and information on 131 popular cut flowers and houseplants. A program on selecting landscape plants includes short video segments on the plant selection process, a plant sorter, picture album, and information on the 141 trees, shrubs, vines, and ground covers. Horticulture questions are among those answered in a section on questions most often asked of extension agents. This horticulture information program is one of the top two programs used in the Public Information Interactive Video System in Virginia.

# ESTABLISHING AN INTERDISCIPLINARY RESEARCH TEAM TO ADDRESS HUMAN ISSUES IN HORTICULTURE

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Developing the Interdisciplinary Research Team of the Office of Consumer Horticulture has proven to be very effective at Virginia Tech. Established with the support of the Director of the Agricultural Research Station and the Dean of Research, the initial team was gathered based on their diverse fields and a common "interest" in plants. This core group consisted of three horticulturists, a landscape architect, a psychologist, a sociologist, and an Extension administrator. A campus-wide promotional mailing brought several new members. Members were also invited to join based on their human-factors research activities as reported in campus media. There are currently 19 members; they have actively pursued cooperative research projects to keep costs at a minimum. Members have conducted a 100-participant campus workshop as well as the national symposium, "The Role of Horticulture in Human Well-Being and Social Development," and are currently working on ten research projects which will help develop methods and data valuable for learning about the effects of horticulture on human life quality.

## 358 (PS IV)

### CONSUMER NUTRIENT MANAGEMENT CALENDAR

P. Diane Relf\* and David McKissack, Dept. of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

The Virginia Gardener Nutrient Management Education Program addressed non-point, urban-runoff pollution of Virginia's streams, estuaries, and groundwater, and included a calendar aimed at alerting the garden consumer to the connection between overfertilization and water pollution. Over 15,000 calendars were requested.

A survey of calendar recipients was conducted. 1500 persons were chosen at random, a subsequent address check confirmed adequate distribution among the regions of the state. The response rate was 28%. Responses indicated that 91.3% of those surveyed had changed their garden practices in some way because of the calendar. 90% of the respondents indicated that the calendar had shown them a connection between proper gardening techniques and water quality, with 82.2% indicating the calendar had been moderately to greatly successful in showing them this connection.

The 1989 Virginia Gardener Calendar was an effective method of educating garden consumers about the connection between water quality and nutrient runoff, and cultural practices which lessen the need for fertilizer in the home garden.

## 359 (PS IV)

### A FEASIBILITY STUDY ON A STATEWIDE YARDWASTE COMPOSTING PROGRAM FOR VIRGINIA

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The Commonwealth of Virginia has mandated a recycling goal of 10% of municipal solid waste (MSW) by 1991, 15% by 1993, and 25% by 1995. Yardwaste (leaves, grass clippings, shrub and tree prunings) comprises 15% to 20% of MSW going to landfills daily. Yardwaste can be recycled by collecting material, piling it into large windrows, and allowing it to decompose by composting. The finished product can be used as a soil amendment by nurseries, landscapers, farmers, local/state government projects, and homeowners.

The Virginia Co-op. Ext. Service at VPI&SU was authorized to perform a feasibility study on implementing a statewide yardwaste composting program. The methods included a literature review, site visits in other states to assess technologies, and surveys to determine potential uses and users of composted yardwaste in Virginia.

The study was presented to the Virginia Dept. of Waste Mgmt. in November 1989, and as House Document No. 34 to the Virginia General Assembly. Three bills and one joint resolution are pending.

## 360 (PS IV)

### ENCLAVE EMPLOYMENT OF DISABLED INDIVIDUALS IN A UNIVERSITY GROUNDS MAINTENANCE DEPARTMENT A CASE STUDY

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In 1986, VPI&SU contracted with the New River Valley Workshop for a pilot project to determine the effectiveness of "enclave

placement" in its landscape maintenance program. An enclave of five disabled adults and one working supervisor were employed to assist Virginia Tech's Grounds Department by working as a crew in litter removal, weeding, raking leaves, and shoveling snow.

The enclave was enthusiastic, dedicated, and had low absenteeism, thereby setting a standard for salaried employees. The enclave's participation in the Virginia Tech grounds maintenance program enabled many of the salaried employees to dedicate their time and energy to more complicated tasks.

The pilot project led to a contract that has been effective for four years, proving that disabled adults can function together as a team and, at the same time, be an integral part of a large grounds maintenance department.

## 361 (PS IX)

### SPATIAL AND TEMPORAL TEMPERATURE VARIATION IN A GREENHOUSE

Mark A. Rose and John W. White, Department of Horticulture, Pennsylvania State University, University Park PA 16802.

Temperature affects all major plant physiological processes. Traditional methods of controlling greenhouse temperatures use aerial sensors that do not monitor temperatures within each component of the soil-plant-atmosphere continuum.

Bench, pot, plant canopy, and aerial temperatures were monitored using thermocouples and thermistors processed by environmental computers during a wide range of greenhouse conditions. These include diurnal cycles of high and low solar radiation, night periods with and without artificial lighting, and various ventilation and heating conditions. Spatial temperature gradients of 10-22 °C were discovered during both day and night conditions. These spatial variations cause significant differences in average temperatures between and within benches over diurnal and even seasonal cycles.

Preliminary surveys of microclimatic variations that occur within the greenhouse experimental area are essential for choosing the proper experimental design. Continuous environmental monitoring during the experiment is necessary for interpreting experimental results.

## 362 (PS VII)

### EFFECT OF PHYLL SET (GA<sub>3</sub> + NAA) ON FRUIT SET, YIELD AND FRUIT QUALITY OF CITRUS.

Makki A. Al-Khafaji\* and M. M. Musalat, College of Agriculture, University of Baghdad, Abu-Ghraib, Baghdad, IRAQ

Application of Phyll set (GA<sub>3</sub> + NAA) on whole trees of local cultivars of sweet orange (*Citrus sinensis* Osbeck) and lemon (*C. Limon* Burmann) at full bloom stage was made during 1988 and 1989 seasons. All concentrations of Phyll set (12, 24 and 48 mg/l) increased fruit set and yield of sweet orange. Lemon yields were increased only at 12 mg/l Phyll set. The use of Phyll set as a new growth regulator for improved fruit quality will be discussed.

## 363 (PS IX)

### THE EFFECT OF SEVERE PRUNING ON THE NEW GROWTH OF TWO TREE SPECIES.

Mary Ann Rose\* and Larry J. Kuhns, The Pennsylvania State University, University Park, PA 16802.

Large bare-root liners of *Gleditsia triacanthos* 'Moraine' and *Pyrus calleryana* 'Aristocrat' were planted in spring, 1989. Five trees of each species were pruned by removing 50% of the length of each shoot at planting; 5 control trees were not pruned. After 4 months the trees were harvested and the following measurements were taken on the season's new growth increment: total number of elongated shoots and unelongated shoots (< 1 cm in length), total and average length of elongated new shoots, stem and leaf dry weights.

Growth responses of the 2 species to treatments were nearly identical. Pruned trees had fewer shoots than controls but a much higher proportion of elongated to unelongated shoots. This could be the result of a release of apical dominance. The average new shoot length of pruned trees was 2-3 times that of controls, and the total new shoot length was significantly greater. New stem dry weights of the pruned trees were also greater than the controls, but leaf dry weights were not significantly different. Total shoot weights (stems plus leaves) were not different. In this study there was no difference between treatments in the total seasonal growth increment as measured by weight. An equivalent amount of new growth was distributed on fewer, but more rapidly-elongating branches in the pruned trees.

## 364 (PS IV)

## TEN NOTABLE WOMEN HORTICULTURISTS IN THE HISTORY OF HORTICULTURE

David R. Hershey, Department of Horticulture, University of Maryland, College Park, MD 20742-5611

There are many notable women horticulturists who deserve greater recognition in college horticultural curricula. Ten notable women in horticultural history, listed alphabetically, are,

1. Jenny Butchart (1868-1950) - Created Butchart Gardens.
2. Beatrix Farrand (1872-1959) - American landscape gardener, famous for Dumbarton Oaks and many other landscapes.
3. Annie Jack (1839-1912) - Canadian horticultural author.
4. Gertrude Jekyll (1843-1932) - English landscape gardener.
5. Martha Logan (1702/04-1779) - Pioneer nurseryman.
6. Jane Loudon (1807-1858) - English horticultural author.
7. Isabella Preston (1881-1965) - Canadian plant breeder.
8. Theodosia Burr Shepherd (1845-1906)- Pioneer California flower seed grower/breeder and retail florist.
9. Harriet Williams Russell Strong (1844-1926) - Pioneer in irrigation and in the California walnut industry.
10. Cynthia Westcott (1898-1983) - The plant doctor.

## 365 (PS IV)

## SOURCES OF PLANT HUMOR FOR USE IN HORTICULTURAL EDUCATION

David R. Hershey, Department of Horticulture, University of Maryland, College Park, MD 20742-5611

Research indicates that humor is an effective method to reinforce learning, yet humor is rarely used in horticultural textbooks. Use of humor in horticulture is easier than in many disciplines because humor dealing with plants is less likely to offend specific population segments since plants, not people, are usually the butt of the jokes. A large collection of plant humor has been assembled, including the following: Edward Lear's 32 line drawings of "Nonsense Botany", e.g. Manyepelia upsilonia; Gary Larson's macabre Far Side cartoons dealing with plants, e.g. the "Venus kidnap"; periodic tables of vegetables and of fruits & nuts; Arcimboldo's Renaissance paintings of faces composed of flowers, vegetables, and plant parts and their modern imitations; Robert Wood's book, How to Tell the Birds From The Flowers, containing drawings and poems; Axel Erlandson's fantastically grafted trees; plant movies like the two versions of Little Shop of Horrors, which is set in a flower shop; Joke Fountains of the Renaissance; and numerous cartoons from science periodicals.

## 366 (PS IV)

## "HERB" AND "HERBACEOUS" AS EXAMPLES OF HORTICULTURAL TERMS WITH MULTIPLE DEFINITIONS

David R. Hershey, Department of Horticulture, University of Maryland, College Park, MD 20742-5611

Scientific terms should have a single definition to avoid confusion. The noun "herb" has two broad categories of definitions, the first as a plant used in perfumery, as a dye, in cooking as flavoring, etc. and the second as a description of plant habit. Examination of over 30 definitions for the latter meaning of herb revealed great differences. Herb is variously defined as a "nonwoody plant" or as a plant with "annual aboveground stems", allowing woody plants with annual stems to be called herbs, e.g. Buddleia or Vitex in colder climates. Other definitions restrict herbs to certain portions of the plant kingdom, such as "seed plants" or "vascular plants". The adjective "herbaceous" is also defined in numerous ways, e.g. "not woody", "dying to the ground each year", "having the texture, color, etc. of an ordinary foliage leaf". The same plant may be termed herb or herbaceous using some definitions, but not others. Since herb and herbaceous have been defined in so many different ways, the terms should be avoided, unless the definition being used is given, and more specific terms used, e.g. nonwoody plant.

## 367 (PS IX)

## APPLE ROOTSTOCK PERFORMANCE

C. A. Mullins\* and R. A. Straw, Department of Plant and Soil Science, University of Tennessee, Crossville, TN 38555

Nine size controlling apple rootstock were evaluated in trials initiated at the Plateau Experiment Station, Crossville, TN in 1981 using 'Starkspur Supreme Delicious' as the scion cultivar. Tree survival was poor with M.9 EMLA, Ottawa

3, M.27 EMLA, and Mark rootstock. Trees on M.27 EMLA and Mark were extremely low in vigor and yields. Root suckering was severe with MAC 24 and M.7 EMLA. Trees on M.26 EMLA were the most productive over six fruiting years. Fruit from trees on Ottawa 3 tended to be firmer and have more red color than fruit from trees on the other rootstock when harvested on the same date. Fruit size did not vary due to rootstock over the six fruiting years.

## 368 (PS IX)

## VEGETABLE TILLAGE METHODS AND WATER QUALITY

C.A. Mullins (1) \*, C. R. Mote, R. A. Straw (1), D.L.Coffey, G. M. Lessman, and J. G. Graveel, Departments of Plant and Soil Science and Agricultural Engineering, University of Tennessee, P. O. Box 1071, Knoxville, TN 37901 and Rt. 9, Crossville, TN 38555 (1), and V. D. Adams, Center for Management, Utilization, and Protection of Water Resources, Tennessee Technological University, Box 5033, Cookeville, TN 38505

Tomatoes and sweet corn grew and produced equally well under no-tillage and conventional tillage methods in 1989. Simulated rainfall was applied through an overhead irrigation system four times during the growing period with 2.8 cm of water applied during each event. Total solids in collected runoff water were higher with conventional tillage than with no-tillage. Residue levels of atrazine, metolachlor, mancozeb, esfenvalerate, metribuzin, and metalaxyl and concentrations of N, P, and K in runoff water were determined and varied with runoff event, pesticide, nutrient, crop, and tillage method.

## 369 (PS IX)

## ABSTRACT

## WITHDRAWN

## 370 (PS IX)

## ASPEN WOOD CHIP AND STONE MULCHES FOR ORNAMENTAL PLANTINGS IN INTERIOR, ALASKA

Patricia S. Holloway\* Division of Plant and Animal Science 309 O'Neill Resources Building University of Alaska, Fairbanks, Alaska 99775.

Five woody ornamentals *Rosa rugosa*, *Cotoneaster acutifolia*, *Malus baccata*, *Picea glauca* and *Pinus contorta* var. *latifolia*, were grown for 4 seasons mulched with one of five treatments: 2.5 cm or 5 cm of crushed basaltic quarry stone, 5 cm or 10 cm of quaking aspen wood chips, and an unmulched control. Maximum soil temperatures at the 10 cm depth on the wood chip plots were decreased by as much as 8°C over control plots, and soil moisture was increased. Stone mulch plots showed a slight increase in both temperature and moisture. Soil minimum temperatures were lower on the wood chip plots than the other treatments early in the season, but were slightly higher in September. Soil pH and available N, P and K did not differ among mulch treatments. Weed growth was suppressed by all mulch treatments but was best controlled on the wood chip plots followed by the 5 cm stone plots. Plant growth for all species except *Rosa rugosa* was greatest on the stone mulch plots. Roses growing on the stone mulch plots and the control were subject to significant dieback from winter injury and did not show any difference in total growth after 4 years when compared with the wood chip plots. Plants grown on the wood chip plots exhibited varying degrees of nitrogen deficiency which may be related to reduced nutrient uptake in cooler soils or to a significant amount of rooting in the mulch-soil interface.

## YIELD OF 'QUINAULT' OVERBEARING STRAWBERRIES USING MULCHES AND ROW COVERS IN INTERIOR, ALASKA

Grant E.M. Matheke, Patricia J. Wagner and Patricia S. Holloway\*  
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University of Alaska, Fairbanks, Alaska 99775.

Yields of 'Quinalt' overbearing strawberries were compared during three seasons for plants grown under eight different mulch treatments with or without polyethylene row covers. In 1987, yields using clear polyethylene mulch with or without row covers (3.81 kg/m<sup>2</sup> and 3.45 kg/m<sup>2</sup>, respectively) were significantly greater than all other mulch treatments. Yields ranged from 1.05 kg/m<sup>2</sup> to 2.60 kg/m<sup>2</sup> for black polyethylene; black over white two-sided, embossed polyethylene; black latex liquid; permeable landscape fabric; white over black two-sided, embossed polyethylene mulch, all with row covers or the unmulched control plot without a row cover. During the second year, yields using clear polyethylene mulch were significantly greater than all treatments except for black polyethylene (5.32 kg/m<sup>2</sup> and 4.74 kg/m<sup>2</sup>, respectively). Yields for the other mulch treatments ranged from 3.55 kg/m<sup>2</sup> to 3.85 kg/m<sup>2</sup>. The summer of 1988 was warmer than average which may account for the improved performance of the black polyethylene mulch. In 1989 results were similar to 1987 in which the clear polyethylene mulch had significantly higher yields (5.66 kg/m<sup>2</sup>) than all other mulches (2.12 - 4.31 kg/m<sup>2</sup>). Clear polyethylene mulch with or without row covers is recommended for overbearing strawberry production in Alaska.

## MANUSCRIPT PEER REVIEWS: DO THEY ENHANCE HORTICULTURE OR CONCEAL FRAUD?

Bruce M. Pollock, 3095 Denton Ave., Boulder, CO 80303

The process of peer reviewing manuscripts is frequently considered to be a time-consuming chore. It is, however, critical in maintaining the quality of the society's journals and the respect of the scientific community for the members of the society. The purpose of peer reviews is to insure that the research and resultant paper represent sound and state-of-the-art science. Failure of a paper to achieve this level of excellence, and its subsequent inclusion in the scientist's publication list, essentially falsifies the scientist's credentials and makes each subsequent "promotion based on those credentials an act of fraud. Since almost all horticultural scientists engaged in research are employees of state or federal agencies, these acts of fraud are against the public agencies and the taxpayers. The editor of the society's journals has recently spoken out against below-standard peer reviews. Unfortunately, the type of peer reviews to which he refers are typical of those I have encountered throughout my 30 years experience with horticulture. I suggest it is time that the members of the ASHS look carefully at the situation before a congressional committee does.

## 32 ORAL SESSION (Abstr. 375-382) COLLEGIATE BRANCH FORUM I

## SYNTHESIS OF AN AMPHIDIPOID BRASSICA SPECIES

Tamara Thomsen\*, Department of Horticulture, University of Wisconsin-Madison, Madison, Wisconsin 53706 (T.C. Osborn, Faculty Advisor).

Stock species of *Brassica rapa* and *Brassica nigra* were crossed with the intention of synthesizing the amphidiploid species *Brassica juncea*. Of the stock species, a diploid and a tetraploid were given of both the *B. rapa* (Aaa and Aaaaa) and the *B. nigra* (Bbb and Bbbbbb). However the identity of these was concealed, and they were presented as 1A1, 1A2, 1A3, and 1A4. The objective of this experiment was not only to synthesize the species *B. juncea* (Abaabbb), but to determine the identity of 1A1, 1A2, 1A3, and 1A4 as to which of these were the diploid and tetraploid species, and to test the synthesized *B. juncea* by crossing it with the natural, male sterile *B. juncea*.

## EFFECTS OF LEAF REMOVAL ON YIELD AND FRUIT QUALITY OF 'RIESLING' AND 'CHARDONNAY' GRAPES.

Christopher D. Gran\*, Rea Jean Lonneman and Emily E. Hoover,  
University of Minnesota, Department of Horticultural Science, 306 Alderman Hall, 1970 Folwell Ave., St. Paul, MN 55108

Leaf removal has been reported to be beneficial to fruit quality of several grape cultivars. However, climatic conditions, time of leaf removal and genotype have a strong influence on the effect of leaf

removal on fruit quality traits, such as soluble solids and titratable acidity. The effect of leaf removal on fruit quality of two vinifera grape cultivars grown in Minnesota was examined in this study. The first six basal leaves were removed from four canes on each vine of 'Riesling' and 'Chardonnay'. Leaf removal was carried out at two different times after the onset of veraison—early August (8/2) and late August (8/23). Fruit was harvested in late September and yield and fruit quality data were recorded. The results of the 1989 study will be discussed here. Leaf removal did not significantly affect yields obtained from either cultivar, regardless of leaf removal date. Early leaf removal on 'Chardonnay' vines resulted in significantly higher soluble solids and significantly lower titratable acidity than that observed for fruit of control or late removal treated vines. Similar results were observed for 'Riesling', however the differences were not significant. Data from 1989 and 1990 will be presented and discussed in the talk.

DESCRIPTION OF FLORAL AND FRUIT MORPHOLOGY OF THE MALE-STERILE<sup>15</sup> (MS-15) MUTANT AND ITS ALLELES (MS-15<sup>26</sup>, MS-15<sup>47</sup>, AND ISRAELI-MS) IN TOMATO

Jon M. Kanagy, Department of Horticulture, Purdue University, W. Lafayette, IN 47907 (E. C. Tigchelaar, Faculty Advisor)

**Abstract.** Many genes conditioning male sterility have been reported in the tomato. This study describes the male sterile gene ms-15 and three independently reported alleles (ms-15<sup>26</sup>, ms-15<sup>47</sup>, and Israeli-ms). All alleles at the ms-15 locus differ phenotypically from normal fertile flowers primarily in stamen structure. Stamens of the mutant plants were reduced in size, twisted, seldom connate, and often adnate to the pistil. Further, stamens often bore external ovules and flap-like structures on the adaxial surface. Variation in these abnormalities between the alleles of ms-15 will be discussed.

Fruit "zippering" and catfacing is commonly observed in fruit which results from manual pollination of male sterile flowers. The extent of these abnormalities varies with male sterile genotype and is not observed in the resulting F1 hybrids. It is suggested that these abnormalities result from adnation of the stamens to the ovary.

## SKIRTING VERSUS UNSKIRTING CITRUS TREES FOR FROST CONTROL

Anastacio P. Naranjo\* and Robert J. McNeil, Crop Science Department, California Polytechnic State University, San Luis Obispo, CA 93407

The purpose of this experiment was to measure the difference in temperatures influenced by skirted and unskirted citrus trees under cold temperatures. Sixty citrus trees (oranges and lemons) planted on a hillside were skirted at 18 inches above ground level for this experiment. The experiment was conducted over 96 days, in which daily minimum temperature readings were taken. In addition to the thermometers, four thermographs were used to record constant temperature and duration of frosty nights.

In 79 of the 96 days of the experiment, the skirted treatment showed an increase in the temperature compared with the unskirted treatment at an average increase of 0.25°F. Statistical differences between treatments ranging from 0.5°F to 0.7°F were found for three different days at temperatures in the 40's. No statistical differences between treatments were found at temperatures in the 30's. The thermograph readings showed no differences in the duration of cold temperatures between skirted and unskirted treatments.

## THE EFFECTIVENESS OF ROW COVERS AS A BARRIER TO INSECT PESTS ON ROMAINE LETTUCE (PARRIS ISLAND COS)

Mark Scaroni\* and Jo Ann C. Wheatley, Crop Science Department, California Polytechnic State University, San Luis Obispo, CA 93407

This project examined a floating row cover as an alternative to chemical use for pest control. Insect and vertebrate pest control was excellent on the covered versus the uncovered crop plants. Average weight, length, and quality were enhanced through the use of covers. The interval of transplant-to-harvest was also decreased. While the cost of row cover use is quite high on a per-acre basis, additional gains in quality, yields, earlier plantings, and earlier harvests may justify the use of row covers as an alternative to chemical control. Although acceptance and use of row covers may ultimately rely on the consumer, demand for organically grown vegetables will warrant further evaluation of row cover materials.

# INFLUENCE OF LIGHT ON IN VITRO ROOT CHARACTER FOR WOODY PLANT MICROCUTTINGS.

Renee Timmermann\* and M.A.L. Smith, Department of Horticulture, University of Illinois, Urbana IL 61801

The structure and quality of the adventitious root system formed on a microcutting stem is crucial to the successful acclimation, survival, and ultimate performance of micropropagated plants. Despite increasing evidence that the rooting method impacts on the character of the framework root system, very little research has elucidated the consequences of standard rooting methods on plant quality and performance. Root initiation on microcuttings is handled by a wide range of strategies in commercial practice. In comparison to in vitro roots, ex vitro roots have smaller root diameters, larger vascular diameters, greater length, more branch root development, and root hairs. One important microenvironmental parameter - light - was investigated to determine its contribution to root character. Typically, in vitro root systems are exposed to light throughout the root initiation period. Parallel treatments were established of in vitro light and dark rooting and ex vitro rooting of four woody species. Regardless of light exposure, the overall diameter of adventitious roots was larger for in vitro treatments than the ex vitro treatment. Vascular development was significantly more advanced ex vitro. These results suggest that light is not a major influence contributing to the differences between ex vitro and in vitro root character.

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# GERMINATION, SEEDLING DEVELOPMENT AND MODULATION OF COWPEA AND PIGEONPEA AT LOW TEMPERATURE

Raymond Baptiste\*, Lurline Marsh, Dyremple Marsh and Farideh Eivazi, Department of Agriculture, Home Economics and Natural Resources, Lincoln University, Jefferson City, MO 65101

There is an increasing number of tropical legumes presently grown under temperate conditions with varying amounts of success. This growth chamber study examines the germination, modulation and  $N_2$  fixation of two cowpea and one pigeonpea genotypes at two temperature regimes, 15/10° C and 20/10° C, day/night. Prior to planting, surface sterilized seeds were inoculated by soaking in yeast mannitol broth containing approximately  $2 \times 10^6$  cells ml<sup>-1</sup> Bradyrhizobium (USDA 3384). Uninoculated control seeds were soaked in sterile water before planting. Air temperature of 15/10° C, day/night delayed seed germination, nodule initiation, and seedling development. Inoculated cowpea seeds planted at the 20/10° C regime attained 50% germination within 9 days, while inoculated pigeonpea took 13 days under similar regime. Bradyrhizobium persistence was not significantly affected by low temperature. The results indicate that nodule development for both crops were inhibited chiefly by a lack of developing root hairs at low soil temperature.

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# YIELD POTENTIAL OF TWO COWPEA CULTIVARS GROWN FOR A CUT AND CARRY FORAGE SYSTEM IN MID-MISSOURI

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The use of cowpea as a forage for Central Missouri has been limited. High mid summer temperatures and frequent drought suggest that an alternative forage for livestock may be advantageous during the hot summer months. The ability of cowpea to withstand drought, high temperature and maintain high foliage protein, justifies research of the forage potential of this crop. Forage yield potential of two cowpea cultivars was evaluated in field experiments in 1968 and 1989. For both years a split plot experimental design was utilized with cowpea cultivar the main plot and harvest date the subplot. Dry matter yields for both cultivars were similar at the early harvest dates. However, both fresh and dry shoot yields of Vita 3 (V3) were significantly higher than that of California Blackeye #5 (CB #5) at the later harvest stages. CB #5 plants produced a significantly higher stem dry weight while V3 produced higher leaf dry matter. Foliage regrowth after clipping was substantial for both cowpea cultivars. However, V3 produced 30% higher growth than CB #5. In vitro dry matter digestibility (IVDDM) varied with sample date (plant age) and plant parts sampled. IVDDM was 77% for leaves and 60% for stems of CB#5, and 80% for leaves and 65% for stems of V3.

## 8 4 ORAL SESSION (Abstr. 383-389) COLLEGIATE BRANCH FORUM II

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# PROMOTING AWARENESS OF WATER CONSERVATION IN THE LANDSCAPE

Deborah M. Shuping\* and Jeffrey D. Zahner, Department of Horticulture, Clemson University, Clemson, SC 29634-0375

Water conservation is making journal headlines nationwide because of drought, contamination, pollution, and over development. While the idea of

xeriscaping began in the Western United States where landscapes can be truly dry, many water-saving principles apply to the Southeast, where home moisture problems and pest problems associated with moisture are a major problem. A year of drought maybe followed by three years of plentiful rainfall, and conditions are significantly different from the semi-arid regions of the country to which most of the present literature on water conservation is directed.

The purpose of this project was to provide information on water conservation to designers, landscape industry personnel, and homeowners in the Southeast. This was done by compiling recommendations based on research being conducted by professionals in building science, forestry, horticulture, entomology and landscape architecture.

An educational tool addressing the pressing national problem of water conservation with a regional emphasis, this project was designed to help readers increase landscape water efficiency by 30 to 50% while lowering maintenance costs and insuring greater survivability of landscape plants in times of water shortage. Through careful planning and design, economically attractive and aesthetically sound water conserving landscapes can be created.

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# UTILIZATION OF PLUGS IN PRAIRIE RESTORATION

Sonja Moseman\*, Terry Ferriss, William Kidd, University of Wisconsin, River Falls, WI. 54022 and Carpenter Nature Center, Hastings, MN 55033

The preservation/restoration of prairie ecosystems is part of our responsibility as stewards of the earth. Success in reestablishing prairie plant communities has been quite variable and far from optimum. This cooperative project between the University of Wisconsin-River Falls (UWRF) and Carpenter Nature Center examine the use of horticulture plug technology as a means of improving the quality, availability, production efficiency and transplant survivability of herbaceous prairie species for use in prairie restoration efforts.

Data on growth rates and winter survival of bare-root seedlings and plug seedlings of Rudbeckia hirta, Ratibida pinnata and Zizia aurea in prairie test plots will be presented. The plug seedlings were stockier plants, had well developed root systems, and demonstrated excellent performance as transplants in prairie restoration efforts.

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# A RAPID TEST FOR DETERMINING SEED VIGOR IN RED OAK

Chris Cooper\*, Daniel Struve and Mark Bennett, Department of Horticulture, 2001 Fyffe Ct., The Ohio State University, Columbus, OH 43210.

Previous experiments showed that a 10 day aerated water soak (water priming) increased red oak (*Quercus rubra*) seed vigor. After water priming most seed had split pericarps. Seed with split pericarps were observed to be more visorous than water primed seed without split pericarps. An experiment was conducted to determine if pericarp splitting could be used as an indicator of red oak seed vigor. The following experiment was conducted. Red oak seed from three open pollinated, half-sib families, were water primed for 10 days. Seed were separated into two groups, seed with split pericarps and without split pericarps, and a germination test conducted. Unprimed seed were used as a control. There were significant differences among the families in seed vigor (germination completeness, uniformity and speed). Primed seed with intact pericarps had lower seed vigor than primed seed with split pericarps and unprimed seed. The results suggest that pericarp splitting following water priming is an indicator of high seed vigor.

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# EVALUATION OF AN IRON-STRESS RESPONSE FOR PIN OAK AND RED OAK SEEDLINGS GROWING IN A STATIC SOLUTION CULTURE SYSTEM

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The iron-efficiency of pin oak (*Quercus palustris*) and red oak (*Quercus rubra*) grown in a static solution culture system was evaluated. Treatments included nutrient solutions with no iron, an unavailable iron form ( $Fe_2O_3$ ), and an available iron form ( $FeEDDHA$ ), each adjusted to a starting pH of 5.5 or 7.0. Both oaks grew better when the available form of iron was used than when the solution contained unavailable or no iron. There was no difference in the height or leaf color for plants of either species when grown with unavailable or no iron. Red oak grown with an available iron form significantly lowered the pH of the solution prior to a growth flush. A similar drop in solution pH was not observed for pin oak growing under similar conditions.

### HIGH ROOT-ZONE TEMPERATURE EFFECTS ON DIURNAL WATER USE OF WOODY ORNAMENTAL

B. Jez Lawrence\* and J.M. Zajicek, Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843-2133

Root-zone temperature fluctuations and sap flow rates were characterized for several woody ornamental plants in a controlled environment using a water bath to control temperatures. Flow rates of sap in the xylem were measured every 15 seconds and averaged over 15 minute intervals. Sap flow measurements were correlated to root-zone temperatures recorded during the same time intervals. Whole plant transpiration was measured gravimetrically. Root-zone temperatures were raised from 22°C to 45°C (slightly below lethality between 9:00 am and 12:00 noon, held at that temperature until 4:00 pm, and then allowed to cool. There was a pronounced diurnal change in flow rate with peak flow during mid-morning declining in mid-afternoon. The decline in the rate of sap flow occurred at a faster rate than the decline in root-zone temperature. This diurnal flow rate was most pronounced during the first 24-hour elevated temperature cycle. Plants maintained at a constant temperature of 22°C showed no such extreme fluctuations in sap flow rate. Stomatal conductance measured with a porometer showed similar trends to whole plant transpiration.

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### GIBBERELIN PROMOTES FLOWER STEM ELONGATION ON THE CHRYSANTHEMUMS

Janice Smith\* and Dr. Marihelen Kamp-Glass, NC Agricultural and Technical State University, Greensboro, NC 27411

Effect of gibberellin (GA) concentration on Chrysanthemum (Pink Adorn, White Adorn, Daisy Royal, and Target) were investigated. The controlled and noncontrolled were observed. GA 1.5 was applied to the noncontrolled garden mums at 1, 2, 5, and blank ppm concentrations. The controlled and noncontrolled was evaluated after one week. Normal growth rate on controlled. Growth rate on noncontrolled at 1, 2, and 5ppm was evidently accelerated on all varieties, while GA blank decreased the growth rate of all varieties. GA at 1, 2, and 5ppm affected the Target variety more than any other variety.

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### THE EFFECT OF CUPULE REMOVAL AND SEED HYDRATION ON THE GERMINATION OF TRIPSACUM DACTYLOIDES SEEDS

Jennifer Heisinger\*, Rick Savage, Dyremple Marsh and Fred Hassien, Department of Agriculture, Home Economics and Natural Resources, Lincoln University, Jefferson City, MO 65101

The germination percentage of eastern gamagrass under normal field conditions ranges from 5 to 10%. These rates are considered low and methods to improve stand establishment in this species are necessary. Studies were initiated to determine if cupule removal and seed hydration were effective in improving the germination percentage of eastern gamagrass. Seeds from which the cupules were removed were incubated for 30 days at 5° C in 100% ethylene glycol (EG). Control were seeds incubated in distilled water. At 12, 18, 24 and 30 days after the start of incubation, seeds from each group were removed and subjected to rapid warming at 25 - 27° C. Cupule removal significantly increased seed germination by as much as 55% over the control. Seeds with cupule removed and incubated in EG had a 65% germination rate.

## 33 ORAL SESSION (Abstr. 391-397) FRUIT CROPS: GROWTH AND DEVELOPMENT I

3 9 1

### PHOTOPERIOD EFFECTS ON REPRODUCTIVE DEVELOPMENT OF RABBITEYE BLUEBERRY

Rebecca L. Darnell, Fruit Crops Department, University of Florida, Gainesville, FL 32611

Containerized 'Climax' and 'Beckyblue' rabbiteye blueberry plants (*Vaccinium ashei* Reade) were exposed to 5 weeks of natural daylengths (i.e. gradually decreasing daylengths from 12 to 11 hr) or shortened daylengths (i.e. gradually decreasing daylengths from 10 to 8 hr) starting October 1. 'Beckyblue' initiated twice as many flower buds under short days compared to longer days. The following spring,

'Beckyblue' plants exposed to shortened photoperiods the previous fall had a greater percentage of floral budbreak (based on the number of flower buds formed within each treatment) and a shorter, more concentrated bloom period than did plants exposed to longer photoperiods the previous fall. Fresh weight per berry increased following the short fall photoperiod treatment, despite the fact that fruit number was higher. 'Climax' did not respond to the photoperiod treatments in any way. Leaf carbon assimilation rates of both cultivars increased under short days, but there was no detectable effect of photoperiod on current carbon partitioning in either cultivar, suggesting that flower bud initiation is not limited by current source leaf assimilate supply under these conditions.

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### PHOTOPERIODIC REGULATION OF VEGETATIVE GROWTH AND GIBBERELLIN METABOLISM IN STRAWBERRY

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Photoperiod is an important environmental signal for regulating developmental patterns in many plant species. In several species, photoperiodic regulation of gibberellin A<sub>1</sub> biosynthesis has been implicated as the mechanism by which photoperiod may alter development. To examine this phenomenon in strawberry, *Fragaria virginiana* plants grown under long day (LD) and short day (SD) conditions with equivalent total PAR were examined to determine changes in vegetative growth and GA<sub>1</sub> biosynthesis.

LD conditions (16 hr) promoted vegetative growth. Runner production, total leaf area, area of individual leaves, and petiole lengths, all increased under LD conditions. No runner production occurred under SD conditions (8 hr); however, the number of branch crowns increased.

Gibberellins A<sub>1</sub>, A<sub>20</sub>, A<sub>24</sub>, and A<sub>28</sub>, all from the GA<sub>1</sub> biosynthetic pathway, were identified in plants under both LD and SD conditions. However, SD conditions appeared to affect the 2β-hydroxylation of GA<sub>20</sub> to GA<sub>1</sub>. Whereas levels of most GAs decreased under SD conditions, levels of GA<sub>20</sub> increased, and only trace amounts of GA<sub>1</sub> were found, indicating a possible blockage of the pathway at this point. As GA<sub>1</sub> is considered the active component of the pathway, blockage of GA<sub>20</sub> conversion under SD conditions may explain the concomitant reduction in vegetative growth.

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### INFLUENCE OF GENOTYPE AND ENVIRONMENT ON YIELD COMPONENTS OF PRIMOCANE-FRUITING RED RASPBERRIES WITH EMPHASIS ON TEMPERATURE AND DAY LENGTH

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'Autumn Bliss', 'Heritage' and 'Redwing' were grown in a controlled environment setting at three day/night temperature regimes (30/25, 25/20, 20/15°C) at either 12 or 16 hour photo periods. Vegetative (height, diameter, node number, leaf area, leaf, cane and root dry weight) and reproductive (precocity, numbers of fruiting laterals, flower number and dry weight) parameters were analyzed. Optimum vegetative growth was obtained when plants were subjected to short photoperiods (12 hrs) and cool (20/15°C) or moderate (25/20°C) day/night temperatures. Reproductive characteristics were enhanced when grown under long photoperiods (16 hrs) and moderate temperatures. High temperatures (30/25) reduced cane height due to a decrease in internode length with the greatest reduction occurring under long photo periods. Precocity and flowering was enhanced by long photoperiods especially at cool and moderate temperatures. This may have implications for the reproductive potential of these cultivars when grown in north temperate areas where high temperatures are common for most of the summer.

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### LEAF CHARACTERISTICS OF FRUITING AND DEFLOWERED RED RASPBERRY CANES OVER THE COURSE OF THE GROWING SEASON

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In the early spring, 300 canes of 'Meeker' red raspberry were tagged and 150 were deflowered at anthesis. During a 12-week period beginning at anthesis, leaves were sampled for anatomical sectioning and determination of chlorophyll content and dry weight per leaf unit area.

Comparisons of leaf cross-sections from fruiting (F) and deflowered (DF) canes demonstrated high levels of starch accumulation in the latter. This accumulation of starch was layered throughout the cross section, and size of starch crystals varied by location. Dry weight per leaf unit area increased in all leaves during the season, but was consistently greater in leaves of DF canes throughout the season.

Total leaf chlorophyll and chlorophyll a content increased until reaching a maximum three weeks after anthesis. Both decreased slightly until nine weeks after anthesis and sharply thereafter as leaves began to senesce. Chlorophyll b content remained nearly constant until eight weeks after anthesis at which time levels declined during the onset of senescence.

## FIELD RESPONSE OF MICROPROPAGATED CRANBERRY

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A project to determine the comparative growth response of micropropagated (MP) and field propagated (FP) cranberry plants was conducted in field plots at a commercial cranberry marsh. Microcuttings were derived from shoot culture and rooted in either plugs or peat pots filled with peat. Replicated 1 m<sup>2</sup> plots of MP plants and 15 cm FP cuttings were planted in June. Survival of MP plants after one month was significantly greater than that of the FP plants. Significant growth differences were observed later in the season. The MP plants produced more branches and greater runner elongation, resulting in a much greater ground cover. Many of the FP plants flowered and produced fruit, while the MP plants produced neither. Far fewer new flower buds were set in the fall on the MP plants. Potential advantages of MP cranberries include the fast, uniform establishment of new marshes and consequently earlier achievement of full productivity, and the rapid introduction of new genotypes from breeding or genetic engineering.

ROOT CO<sub>2</sub> EFFECTS ON THE PEACH ROOT SYSTEM

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Carbon dioxide is produced by microbial and plant respiration and accumulates in the soil. In previous field studies, CO<sub>2</sub> levels were higher under a killed sod soil management system, relative to cultivation and herbicide systems (1.8 vs 0.8 and 1.0%), respectively. Our objective in these studies was to measure the effect of elevated levels of root system CO<sub>2</sub> on root and shoot growth and nutrient uptake. Using soil and hydroponic systems in greenhouse studies, we maintained root system CO<sub>2</sub> levels between 1.5 and 2.5%. Control CO<sub>2</sub> levels were less than 1%. Root length density and dry matter partitioning to the root system were increased by root CO<sub>2</sub> in soil and hydroponic studies; shoot growth was unaffected. In hydroponic culture, root CO<sub>2</sub> increased P uptake, solution pH, root volume and the number of lateral roots/cm root axis. Elevated levels of CO<sub>2</sub> in the root system stimulated root growth in both the soil and hydroponic studies.

## EFFECT OF LACTIDICHLOR ETHYL AND GIRDLING ON FRUIT SET, FRUIT SIZE, AND MATURITY OF PEACH.

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Mature 7-year-old 'Raycrest' peach trees (*Prunus persica* [L.] Batsch) were treated at prebloom and late postbloom with foliar sprays of lacticidichlor ethyl at 0, 25, 50, 75 and 100 mg-liter<sup>-1</sup>. A trunk girdling treatment was also included. Lacticidichlor ethyl treatments had no effect on fruit set, fruit size and maturity. Girdling trees 30 days postbloom increased fruit size and enhanced maturity, but had no effect on fruit set. These results suggest that fruit size and maturity are enhanced by girdling.

## 34 ORAL SESSION (Abstr. 398-405) VEGETABLE CROPS: CULTURE AND MANAGEMENT I

## CARBON DIOXIDE ENRICHMENT OF VEGETABLE CROPS GROWN UNDER TUNNEL CULTURE

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A study was conducted to determine the feasibility of field-scale CO<sub>2</sub> enrichment of vegetable crops grown under tunnel culture. Cucumber, squash and tomato were grown under polyethylene tunnels in a manner similar to commercial practices in southern California. The buried drip irrigation system was used to uniformly deliver an enriched CO<sub>2</sub> air stream independent of irrigation. CO<sub>2</sub> concentration in the tunnel atmosphere was maintained between

700-1000 ppm during daylight hours. Enrichment began two weeks after planting and continued for four weeks. At the end of the treatment phase, enrichment had significantly increased plant dry weights. This growth advantage continued through harvest, with enriched plots yielding 20%, 30% and 32% more fruit of squash, cucumber and tomato, respectively. As performed in this study, the expense of CO<sub>2</sub> enrichment represented less than a 10% increase in total pre-harvest costs. Industrial bottled CO<sub>2</sub> was used in this study; since bottled CO<sub>2</sub> is captured as a byproduct of industrial processes, this usage represents a recycling of CO<sub>2</sub> that would otherwise be vented directly to the atmosphere.

## ASPARAGUS HARVEST DURATION, STORAGE CARBOHYDRATES AND YIELD

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Asparagus (*Asparagus officinalis*) has great potential for production in the southwestern desert areas. Light, moderate and heavy harvest regimes were imposed on a one year old planting of 'Mellowland Select' to determine the optimum duration of Spring harvest. There were no differences in mean spear weight or number of spears per plant in response to cutting pressure in 1987 or 1988. In 1989 both the light and heavy cutting regimes resulted in spears weighing 2.0 and 1.5 grams less, respectively, than the moderate treatment and in fewer spears per plant. Consequently, 587 and 670 fewer kg/ha were produced in the lightly and heavily harvested plots in the third year. Total storage root carbohydrates were higher in the moderately harvested plots prior to harvest and again after fern production resumed in the third year. 1990 harvest data and implications for fall harvested or double-harvested asparagus will be discussed.

## EVALUATION OF PROPAGATING STOCK AND PRACTICES FOR ANNUAL RHUBARB PRODUCTION

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Yield and quality of seed- and vegetatively-propagated rhubarb [*Rheum rhabarbarum* L.] for annual production were evaluated for 4 seasons. Field planting of transplants or crown divisions in late October or early November resulted in harvests beginning in early to late January and continuing until late April. Selection of 'Victoria' seedlings based on petiole color was not effective in increasing the proportion of red mature petioles. Yields from seed-propagated annual 'Victoria' rhubarb were always higher than yields from 'McDonald' single-bud crown divisions and higher than yields from 'McDonald' crown-divisions in one of two years. The four-year average yield for 'Victoria' seed-propagated rhubarb was 20.4 Mg·ha<sup>-1</sup> whereas 'McDonald' crown-division-propagated rhubarb had a two-year average yield of 15.8 Mg·ha<sup>-1</sup>. On the other hand, petiole color of vegetatively-propagated rhubarb was always superior to that of seed-propagated rhubarb. GA applications increased early yield from 'McDonald' single-bud divisions, but reduced early and total harvest petiole weight.

## TOMATO MATURITY IN RELATION TO PRUNING AND CULTURE

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Three different cultural methods were utilized in the evaluation of 150 indeterminate tomato hybrids. This study was conducted over a two year period. The hybrids were planted in the field through 1.52 m wide black plastic; (1) 30.5 cm apart in rows, trained upright end pruned to one growing point (1gp); (2) 91.4 cm apart in rows, trained upright end pruned to three growing points (3gp); and (3) 91.4 cm apart in rows end permitted to grow prostrate end unpruned (up). Accumulated total harvest patterns were different: August 5 (early yield) of the first year, the yield of all ripe or turning fruit was 2.43, 0.36 and 0.24 kg/m<sup>2</sup> respectively; the yield resulting from pruning to 1gp was 6.75 X the yield of the plants with 3gp. Yields of plants with 1gp were 3.6 X and 2.6 X the yield of plants with 3gp, 20 and 40 days later respectively. The yield of the plants up were the lowest in early maturity but 40 days later surpassed the yield from plants with 1gp by 2.6 kg/m<sup>2</sup>.



# TRAY COLOR INFLUENCES GROWTH AND QUALITY OF LETTUCE AND TOMATO TRANSPLANTS.

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Two cultivars of tomato (*Lycopersicon esculentum*) and leaf lettuce (*Lactuca sativa*) were evaluated using two plug trays, polyethylene and polystyrene in two colors, black and white. Cells were 2 cm square inverted pyramid and 5 cm deep. Temperatures 0.3 cm below the surface of the media in the black trays average 2 to 4°C warmer than in the white trays. Night temperatures were not influenced by tray color. There was no apparent interaction between color and tray composition. Tomato plants grown in black trays had longer, smaller diameter stems than those in the white trays. Total leaf area, plant fresh and dry weights, however, were not affected by tray color. Leaf lettuce grown in black trays had greater total leaf area than those in white trays. Leaf numbers were not affected by tray color. Plants of tomato and lettuce grown in white trays were shorter, stockier, and easier to handle during transplanting than those produced in black trays. Both cultivars of tomato and lettuce responded similarly to tray color and composition.

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### INFLUENCE OF TRANSPLANT AGE AND CONTAINER SIZE ON BROCCOLI PRODUCTION

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Four experiments were conducted to evaluate the influence of transplant age and container size on 'Green Duke' broccoli production. Transplant ages (weeks from seeding) were 3, 4, and 5 weeks in Exp. A, 4, 5, and 6 weeks in Exps. B and D and 3, 4, 5, and 6 weeks in Exp. C. Cell sizes were 2.0 cm (width) × 3.2 cm deep (2.0 cm), 2.5 cm × 7.2 cm deep (2.5 cm), and 3.8 cm × 6.4 cm deep (3.8 cm) with each transplant age. With the smallest container size (2.0 cm), yields were significantly lower in 3 of 4 experiments as compared to the 3.8 cm container size. In 2 of 4 experiments, yields were lower with the 2 cm size as compared to the 2.8 cm container size. In Exps. A and B transplant age did not influence yield, but use of the oldest transplants in Exp. C resulted in reduced yields while use of the oldest transplants in Exp. D resulted in the highest yields. Generally, head weights followed similar patterns to the yields.

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### PURE STANDS OF CUCUMBER CULTIGENS IMPROVE YIELD OVER MIXTURES

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Mixtures of different cucumber cultivars or breeding lines (collectively called cultigens) has been used commercially in some parts of the U.S. The objective of this study was to determine whether mixtures of cultigens produce higher yields than pure stands. Three cultigen pairs: Gy 14A + M 21, Gy 4 + WI 2757 and Regal + Carolina (higher yielding cultigen listed first) were blended at 0, 25, 50, 75 and 100%, and sown in a spring and summer planting in 1989. Fruit were harvested 6 times in each study and graded according to N. C. standards. Data were collected on yield, earliness, vine size, sex expression and disease resistance. Yields from the spring planting were superior to those from the summer. For maximum fruit weight (Mg/ha), a mixture consisting of 25% of the lower yielding cultigen of each pair should be grown. However, for maximum fruit value (\$/ha), the higher yielding cultigen of each pair should be grown in pure stand. We concluded that arbitrary mixtures of cultivars offer no advantage in most cases, although superior mixtures might be produced by evaluating cultigen pairs for complementation.

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### PLANT SPACING OF 'CALYPSO' AND LITTLE LEAF GENOTYPES OF CUCUMBERS

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Plant spacing or population studies with normal internode-length 'Calypso' and short-internode Ky Littleleaf (Ky-LL), both gynoeious-flowering, in 6-row beds for once-over harvest in 1987, 1988, and 1989 showed that increasing spacing increased leaf area per plant, but had no effect on leaf area, fruit number, and total fruit weight in Grades 1, 2, and 3 per growing area. 'Calypso' plants had more leaf area than Ky-LL, but both had similar number and weight of fruit. The best spacing for 'Calypso' and Ky-LL was 15 x 21.5 cm for an average of 28.5 plants/m<sup>2</sup> (283,570/ha).

Ark Littleleaf (ARK-LL), a monoecious-flowering normal-internode length genotype, had more leaves and greater leaf area than 'Calypso' and KY-LL plants. Increasing bed spacing of Ark-LL plants from 30 × 30 to 30 × 45 cm increased leaf area, fruit number and fruit weight per plant, but not per growing area. For fruit number and weight in Grades 1, 2, and 3, the best row spacing of Ark-LL plants was a single row of 15 cm or a 30 × 30 cm double row with fruit weight of 25,500 and 27,000 kg/ha, respectively. Data for the three plant types in various row spacings to be conducted in 1990 will be presented.

## 35 ORAL SESSION (Abstr. 406-413) CROSS-COMMODITY TISSUE CULTURE I

### 406

#### DENSITY SEPARATION OF ZYGOTIC AND SOMATIC EMBRYOS

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Density changes associated with developing zygotic embryos of loblolly pine (*Pinus taeda* L.) and somatic embryos of celery (*Apium graveolens* L.) were determined using sucrose gradients. Continuous sucrose gradients were used to evaluate relative density of loblolly pine embryos from July 25, when embryos could be microscopically observed, to November 7, 1988. Embryos density declined during development with a maximum (51% sucrose equivalent or 1.2331 g/ml) at first sampling and then remain relatively constant (10% sucrose equivalent or 1.0306 g/ml) after day 49. Density changes were inversely related to embryo length.

Celery somatic embryos, cultured for 6, 8, 10, or 12 days were separated with sucrose solutions varying from 9 to 16% in 1% intervals. Embryos were classified as overmature (expanded cotyledons), mature (torpedo), and immature (globular). The number of low density embryos increased from 6 to 12 days. The highest conversion to normal seedlings after desiccation for 48 hr at 90% relative humidity was obtained with overmature and mature embryos, but some immature somatic embryos also survived. Maximum conversion was obtained from embryos with density equivalent of 12% to 14% sucrose (1.0448 g/ml to 1.0531 g/ml) at days 10 and 12.

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#### EFFECT OF AUXIN SOURCE AND EXPLANT TYPE ON MORPHOGENESIS IN VITRO OF THREE TOMATO INBRED LINES

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Cotyledon explants and zygotic embryos of *Lycopersicon esculentum* H132, OH8442, and OH2253 were cultured on Murashige and Skoog medium containing varying concentrations of 2,4-D and NAA with and without 10<sup>-6</sup> M zeatin. NAA above 10<sup>-6</sup> M and 2,4-D above 10<sup>-6</sup> M inhibited root formation from cotyledons. Zygotic embryos were removed from developing ovules at the globular, heart, and torpedo stages and later germinated on hormone-free medium. Globular structures that resembled immature zygotic embryos were produced at NAA concentrations between 10<sup>-6</sup> and 10<sup>-5</sup> M and 2,4-D concentrations between 10<sup>-6</sup> and 10<sup>-5</sup> M. Treatments reported to enhance maturation and germination of somatic embryos of other species, including subculture to a hormone-free medium with and without activated charcoal, the addition of an ABA treatment subsequent to the auxin treatment, isolation of individual structures from the explant, and a liquid medium rinse containing activated charcoal, have not been successful in stimulating further development of the globular structures.

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#### FACTORS AFFECTING THE REGENERATION OF PEPPER (CAPSICUM ANNUUM L.) J. L. Jacobs\* and C. T. Stephens, Department of Botany and Plant Pathology, Michigan State University, E. Lansing, MI 48824.

Several growth hormone combinations and silver nitrate concentrations were examined for their effect on regeneration of different pepper genotypes. Primary leaf explants from in vitro seedlings were cultured on a revised Murashige and Skoog medium supplemented with auxin, cytokinin and 1.6% glucose. Combinations of different concentrations of indole-3-acetic acid (IAA), 0-5 mg/l, and 6-benzylaminopurine (BAP), 0-5 mg/l, were tested to determine the most effective medium for shoot primordium formation. Experiments with IAA and BAP did not result in a specific growth hormone combination appropriate for regeneration of all genotypes tested. Of the silver nitrate concentrations tested, 10 mg/l resulted in the best shoot and leaf differentiation and reduced callus formation. Differences in organogenic response of individual genotypes were evaluated on a single regeneration medium. Whole plants were regenerated from 11 of 63 genotypes examined. Based on these experiments, a reproducible regeneration system for pepper was developed with a total of 500 plants regenerated to date.

# ORGANOGENESIS IN CULTURED ADVENTITIOUS ROOT SEGMENTS AND IN PROTOPLAST-DERIVED CALLUS OF SWEET POTATO

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One cm segments from adventitious roots of sweet potato (*Ipomoea batatas* (L.) Lam.) will regenerate shoots when cultured on Murashige and Skoog salts and vitamins plus either sucrose (1-3%) or fructose (1-6%). The best source for adventitious roots is sweet potato shoot cultures maintained in Magenta vessels. A low concentration of cytokinin (0.02 mg/liter) promotes shoot formation. Higher levels of cytokinin (0.1-0.5 mg/liter) encourage callus growth. The maximum average number of shoots formed per root segment attained thus far is 0.5. Attempts are being made to increase the frequency of shoot formation. Regeneration of shoots from roots also may be a useful method for obtaining plants from protoplasts of sweet potato. Protoplasts can be isolated from mesophyll tissue and petioles of in vitro grown plants. Plating efficiency of up to 12% routinely can be obtained. Shoot formation directly from callus is sporadic; root formation is more frequent.

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# IMPROVED PLANT REGENERATION OF SOLANUM AND LYCOPERSICON GENOTYPES FROM LONG-TERM CALLUS CULTURE. Chang-Yeon Yu and John Masiunas\*, Department of Horticulture, University of Illinois, Urbana, IL 61801.

Repeated callus sub-culture reduce the regeneration capacity in many species. Our studies determined the effect of genotype and medium on regeneration of several *Solanum* and *Lycopersicon* genotypes from long-term callus cultures. In the first study, 13 genotypes were transferred to regeneration medium, including: Murashige and Skoog plus Gamborg Vitamins (MG); Murashige and Skoog (MS); Gamborg (GM); and white (WM). The greatest shoot regeneration was on the MG medium, containing the highest levels of thiamine. Shoot differentiation was greatest with 0.2 mg/l IAA and 2 mg/l BA. No plants were regenerated on GM or WM medium. In a second study, the effect of thiamine (0 to 200 mg/l) on shoot regeneration of the *L. peruvianum* genotypes PI199380, PI126945, PI251301, and PI28652, along with *Solanum* *ptycanthum*, *Solanum* *nigrum*, and *L. esculentum* 'Diego' was evaluated. Shoot regeneration of *Solanum* *ptycanthum*, *Solanum* *nigrum*, *L. peruvianum* PI 199380 and PI25301 was best with 20 mg/l of thiamine.

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# IN VITRO NITROGEN METABOLISM AND ORGANOGENESIS OF *NICOTIANA TABACUM*

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The role of N metabolism in organogenesis and growth was studied using tobacco pith callus. Callus was cultured on a solid medium containing 10  $\mu$ M (1.75 mg/l) IAA and 2  $\mu$ M (0.43 mg/l) kinetin for 56 days. In the growth experiment, ratios of  $\text{NH}_4^+-\text{N}$  to  $\text{NO}_3^--\text{N}$  (0:60, 20:40, 30:30, 40:20 and 60:0 mM) were supplied by  $(\text{NH}_4)_2\text{SO}_4$  and  $\text{KNO}_3$ . Callus and media were analyzed for inorganic N. Callus supported by 30:30 and 40:20 media removed the highest amounts of  $\text{NH}_4^+-\text{N}$  and  $\text{NO}_3^--\text{N}$  from the media and exhibited organogenesis. Final dry weight was greatest in callus supported by the 30:30 medium. In the organogenesis experiment, the transfer history of the inoculum source affected N uptake, organogenesis and growth. Inorganic N was supplied by  $\text{NH}_4\text{NO}_3$  and  $\text{KNO}_3$ . The net uptake of  $\text{NH}_4^+-\text{N}$  and  $\text{NO}_3^--\text{N}$  was lower in shoot-forming than in root-forming and non-organogenic callus subculture from 7-day-old stock cultures. The final pH of the medium supporting shoot-forming callus was lowest. Growth, on a dry weight basis, was lowest in shoot-forming callus. Callus subculture from 60-day-old stock cultures formed no shoots.

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# IN VITRO FLOWERING OF REGENERATED SPINACH PLANTS J. M. Al-Khayri\*, F. H. Huang, and T. E. Morelock, Department of Horticulture and Forestry, University of Arkansas, Fayetteville, AR 72701

Regenerated spinach (*Spinacia oleracea* L.) maintained under a 10-h photoperiod ( $65 \mu\text{E m}^{-2} \text{s}^{-1}$ ) after an incubation period on a GA-containing medium were induced to flower *in vitro*. The plantlets were regenerated from callus initiated on MS medium with 2.0 mg  $\text{L}^{-1}$  kinetin and 0.5 mg  $\text{L}^{-1}$  2,4-D and were subsequently transferred to a medium containing 2.0 mg  $\text{L}^{-1}$  kinetin, 1.0 mg  $\text{L}^{-1}$  GA, and 0.01 mg

$\text{L}^{-1}$  2,4-D. While on the regeneration medium, the cultures were exposed to a long-day photoperiod. Regenerants were transferred to an IBA-containing medium for rooting, after which flowering was observed. *In vitro* flowering plantlets exhibited male and female flowers depending on the sex of the explant donor. Female plantlets developed seeds in the culture vessels. This method of seed production from regenerants can eliminate time-consuming steps in acclimation, transplanting to soil, and plant maintenance.

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# COMPARISON OF CELL GROWTH IN POLYPROPYLENE CULTURE BAGS VERSUS SHAKER FLASKS

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Gyratory shakers are commonly employed to maintain oxygen levels in plant suspension cultures. Growth of plant cells in semi-permeable polypropylene bags is a potential alternative to this technique. Carrot and tobacco cell cultures were grown in stationary autoclavable polypropylene bags (AgriStar, Inc.) and 125 ml Erlenmeyer flasks on a shaker for up to 56 days. Experimental cultures were inoculated from a common source of exponentially growing cells. Measurements of cell growth were determined by measuring absorbance at 550nm and correlated with actual cell counts. The number of cells grown in polypropylene bags increased at a similar rate to cells grown in flasks during the first 35 days. After 35 days, polypropylene bag cell cultures out-performed flask grown cultures. Flask grown cultures were highly pigmented, an indication of culture senescence.

## 40 ORAL SESSION (Abstr. 414-421) FRUIT CROPS: CULTURE AND MANAGEMENT I

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# THE USE OF ETHEPHON AND NAA AS A HARVEST AID ON PECANS (*Carya illinoensis* Koch.) IN MEXICO

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Ethephon and NAA in 2 combinations were applied to 17 year old "Western" pecan trees near the coast of Hermosillo, in Sonora, Mexico. The treatments were: a) 300 ppm NAA plus 800 ppm Ethephon; b) 300 ppm NAA plus 500 ppm Ethephon. These treatments were applied at three different times: first, when nut physiological maturity was reached, second, 10 days after nut physiological maturity and third, 21 days after physiological maturity was reached. The best treatment was the combination of 300 ppm NAA plus 800 ppm Ethephon applied 10 days after physiological maturity. This treatment resulted in 100% shuck dehiscence, 10% leaf abscission, 2 weeks advance in harvest and the best kernel color when compared to control.

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# CHEMICAL THINNING OF 'GRANNY SMITH' APPLE

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Under California conditions 'Granny Smith' apple does not "self-thin" sufficiently to promote good return bloom nor to provide fruit size desired for the fresh market. Preliminary studies conducted during 1985-87 indicated that 1-naphthyl N-methylcarbamate (carbaryl), 1-naphthaleneacetic Acid (NAA), and 1-naphthaleneacetamide (NAD) could be useful for thinning 'Granny Smith'. Detailed studies conducted in 1988 and 89 using dilute handgun applications demonstrated that all 3 materials provided reasonable thinning as shown by fruit set counts. NAA and NAD tended to slow fruit growth as compared to carbaryl. Carbaryl tended to uniformly thin clusters while NAA and NAD were more likely to remove all the fruit from some clusters and few fruit from others, especially in 1988. Compared to the control, all materials applied in 1988 improved return bloom in 1989 with carbaryl having a slightly greater effect than NAA and NAD. As a result of these studies carbaryl at 1.7 to 2.2 kg (active ingredient) per ha as a dilute application is being suggested for grower trials in California.

# EFFECTS OF HYDROGEN CYANAMIDE ON STONE FRUIT THINNING

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Influence of prebloom and full bloom applications of hydrogen cyanamide on 'Simka' and 'Friar' plums in Southwest Idaho and 'Florida Prince' peach in Southwest Arizona was studied. Prebloom application of 0.5% hydrogen cyanamide caused severe toxicity to the fruit buds in 'Friar' plum, while 2% hydrogen cyanamide did not cause toxicity in 'Simka' plum. 'Simka' fruit was effectively thinned with 1-2% prebloom application. At full bloom, 1.5% hydrogen cyanamide caused severe flower and leaf burning in both 'Friar' and 'Simka' plums, while concentrations between 0.1% and 1% thinned flowers (fruits) in both of the plum cultivars. Influence of hydrogen cyanamide on final fruit set, fruit size and maturity are also studied. Prebloom or full bloom applications of 2% or 3% hydrogen cyanamide eliminated 95 to 100% of the blooms, while application of this chemical at 1% sufficiently thinned the fruit. Number of commercially packed large peaches in trees receiving 1% hydrogen cyanamide was the same as that in trees thinned by hand, suggesting hydrogen cyanamide as a potential chemical for stone fruit thinning.

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# PALMETTE-LEADER (PL) AND CENTRAL-LEADER (CL) TREE-FORM EFFECTS ON LIGHT DISTRIBUTION, PRODUCTIVITY AND FRUIT QUALITY OF 'McINTOSH' APPLE TREES

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Mature 'Macspur McIntosh/MM.106 trees trained to the CL tree form were converted to the PL tree form in 1987 by removal of east- and west-oriented upper scaffold limbs. Control trees were pruned to maintain the CL form. Dormant pruning in later years maintained either tree form. No summer pruning was used in this study. Canopy light levels along horizontal transects at one m above the soil and vertical transects, both through the center of the canopy, were unaffected by tree form or transect direction. Yields were significantly lower for PL trees in 1987 and 1989, while yield efficiency was reduced in PL trees in all 3 years. Fruit size, trunk cross-sectional area, and foliar macro-nutrient content were unaffected by tree form during this study. Fruit color development in both the upper and lower halves of the canopy was uninfluenced by tree form.

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# PERFORMANCE OF MECHANICAL ROOT PRUNING OR HEDGING IN AN INTENSIVE ORCHARD

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In 1981, four apple cultivars were established as a low trellis hedgerow on M.9 or free-standing central leaders on M.7 at the recommended or half the recommended spacing with the close planted trees either root pruned annually at bloom or hedged in August. Planting at half the spacing and annual summer hedging 2 sides decreased TCA 25% and canopy volume 51% with no effect on shoot growth, while annual root pruning decreased TCA 34%, canopy volume 50% and shoot length 25%. Planting at half spacing and either hedging or root pruning reduced yields per tree. Efficiency as measured by yield TCA was decreased by hedging and as measured by yield/m<sup>3</sup> canopy volume was increased by both treatments with hedging having the greatest effect. The cumulative yield/ha was increased by both hedging and root pruning with no difference between them. Fruit size was decreased by close planting and root pruning caused a greater decrease than hedging. Close planting increased the number of spurs and shoots and LAI per unit volume of canopy with no difference between hedging or root pruning. 'Empire' outproduced 'Smoothee' and 'Delicious' on the trellis and 'Lawspur' had higher yields than any other cultivar in the central leader.

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# TREE TRAINING PROCEDURES FOR HIGH-DENSITY SWEET CHERRY PRODUCTION ON VIGOROUS ROOTSTOCKS

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Sweet cherries produce vigorous upright growth from Apr.-Sept. and are slow to bear in California. Our tree training objectives include earlier bearing, easier harvesting, high productivity of good quality fruit. 'Bing' cherry on mazzard and mahaleb rootstock were planted in 7 blocks and trained 6

ways. One group was headed 12-18 inches above the bud union and 4 branches were retained at the 1st dormant pruning. Lateral buds were treated with promalin at bud-break to induce lateral shoot formation. Trees were spring-summer pruned to reduce terminal growth. At the second dormant pruning, strong shoots were removed and lateral shoots were treated with promalin to induce spur formation. Trees were treated likewise through the 3rd dormant season and produced a fair crop in the 4th season. Central leader trees were created by tying/weighting limbs, dormant and summer pruning, and retaining less vigorous limbs as well as utilizing promalin. Slow growing trees tended to bear fruit more rapidly. Both training methods yielded fruit in the 4th season while traditional pruning procedures produced few fruit. Data and procedures will be presented to document these practices.

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# MATURITY RANGE OF FRESH MARKET PEACHES AND DURATION OF PEAK YIELDS FROM ONCE-OVER HARVESTS

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Cultivars of fresh market peaches (*Prunus persica*, L. Batsch) vary in the duration for maximum yields in the shipping stage (firm ripe) from once-over harvests. A cultivar having many firm ripe fruit with few green and over ripe at a given time has a narrow maturity range. It can be picked fewer times, facilitate mechanical once-over harvests and reduce spray costs. Fruit were harvested from small trees or scaffold branches of large trees at 2- to 3-day intervals as once-over harvests on 4 dates to estimate maturity range and duration of the maximum firm ripe fruit. Fruit of 3 cultivars were graded by color into maturity stages: 1) green, 2) firm ripe, and 3) over ripe. 'Loring' had 82% firm ripe sorted in the 1st 3 harvests in 1987 and 1988. 'Redskin' had 83% firm ripe in the 2nd and 3rd harvests in 1987. 'Redglobe' had 85% marketable in the 2nd and dropped to 75% in the 3rd harvest in 1987. 'Redhaven' had about 80% firm ripe in the 1st 3 harvests in 1988. Results indicate that the duration of narrow maturity ranges of 'Loring' and 'Redhaven' would permit them to be harvested over about 5 days with high yields in the firm-ripe stage.

## 41 ORAL SESSION (Abstr. 422-429) CROSS-COMMODITY: BREEDING I

422

# New Sources of Resistance to Black rot in Crucifers and Inheritance of Resistance.

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Resistance to Black rot was studied in *B. oleracea*, *B. campestris* and *B. napus*, using three different inoculation procedures. The results indicated that hydathode inoculation without wounding and the wound suspension technique were useful for differentiating levels of resistance found in *B. oleracea* and *B. campestris*, but not in *B. napus*. Only the wound colony method allowed differentiation between high and moderate resistance in *B. napus*. *B. napus*, PI 199947 and PI 199949, exhibited the highest resistance found in cultivated Brassica species. In *B. campestris*, two Chinese cabbage accessions showed quantitative inheritance for moderate levels of resistance. In *B. napus*, the high level of resistance was conferred by one dominant gene, to which the symbol Br was assigned, whereas the moderate resistance was due to one recessive gene bm.

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# FIELD STUDIES TO QUANTIFY POLYGENIC RESISTANCE IN SPINACH TO WHITE RUST AND DOWNY MILDEW.

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Field observations indicate that polygenic resistance to downy mildew (*Peronospora farinosa* f. sp. *spinaciae*) was observed during the course of a breeding program to develop polygenic resistance to

white rust (*Albugo occidentalis*). Field studies were initiated using five cultivars and one breeding line to quantify the level of resistance to downy mildew and white rust. Separate plots were inoculated with each pathogen at a specific spore concentration and then subjected to a minimum dew period of 12h. Infection was quantified by measuring latent period, lesion number, lesion size, sporulation and percent leaf area infected.

#### 424 SCREENING CULTIGENS OF CUCUMBER AND HORNED CUCUMBER FOR RESISTANCE TO ROOT KNOT NEMATODES

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Root knot, caused by *Meloidogyne* spp. is the most important disease of cucumber (*Cucumis sativus* L.) in North Carolina, causing an average annual yield loss of 12 %. A greenhouse study was conducted 10 screen 924 cultigens (728 accessions, 136 cultivars and 36 breeding lines of *C. sativus*, and 24 accessions of *C. metuliferus* Naud.) for resistance to 3 species of root knot nematodes, *M. incognita* r. 3, *M. arenaria* r. 2 and *M. hapla*. Plants were grown from seed in 150-mm diameter clay pots. Two-week-old seedlings were inoculated with 5000 nematode eggs per plant, then evaluated for resistance 9 weeks later. All cultigens evaluated were resistant to *M. hapla*. Little resistance was found in the cultigens of *C. sativus* to *M. incognita* r. 3 and *M. arenaria* r. 2. Most of the cultigens evaluated were susceptible to both. 'Southern Pickler' was resistant to both nematodes (1 % average galls). 'Green Thumb and LJ 90430 were resistant to *M. arenaria* r. 2. Two check cultigens, 'Sumter' and Wis. SMR 18, had an average of more than 50% galls. All *C. metuliferus* cultigens evaluated were resistant to all root knot nematodes tested. PI 482452 was most resistant (1 % average galls), and PI 482443 was least resistant (5% average galls) of the *C. metuliferus* cultigens tested.

#### 425 EVALUATION OF THE CUCUMBER GERMPLASM COLLECTION FOR RESISTANCE TO ANTHRACNOSE

Todd C. Wehner\* and Jack E. Staub, Dept. Hort. Sci., North Carolina State University, Raleigh, NC 27695, and U. S. D. A./A. R. S., Univ. Wisconsin, Madison, WI 53706

The cucumber (*Cucumis sativus* L.) germplasm collection of 924 cultigens (accessions, breeding lines and cultivars) was evaluated for resistance to anthracnose (*Colletotrichum orbiculare* (Pass.) Ell. & Halst) in the field and greenhouse. The field test was run using 1 m plots grown in 4 environments (year-location combinations). The field was inoculated 3 weeks after planting using a backpack sprayer. A susceptible spreader cultivar (Wis. SMR 18) was planted every 5th row, and plots were overhead-irrigated 3 times/week. Plots were rated 1 and 2 weeks after inoculation. The greenhouse test was run using seedlings grown in flats of vermiculite, and inoculated with  $10^7$  spores/ml on one cotyledon. Plants were rated using the size of the chlorotic halo surrounding the lesion. There was no correlation ( $r=0.04$  to  $0.17$ ) of seedling test with field test ratings, nor between any of the 4 field test environments. Correlations were significant among field tests when only cultivars and breeding lines were evaluated. We concluded that diversity within accessions resulted in the lack of correlation among tests. The cultigens that had high resistance in all tests were 'Slice', NCSU M 21, Gy 14A, 'Addis' and PI 164433 (India). Most susceptible were PI 175696 (Turkey) and PI 285606 (Poland).

#### 426 SCREENING VEGETABLE SOYBEAN CULTIVARS FOR SEED YIELD EFFICIENCY AND CORN EARWORM RESISTANCE

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Vegetable Soybean Cultivars belonging to MG III thru V were evaluated for their Seed Yield Efficiency (SYE) and Resistance to *Heliothis* Zea.

This study was conducted in 1968 and 1969. Each entry was planted in a single row plot. Each plot was 5.0 m long and 0.75 m apart in a randomized complete block design with 4 replications.. All entries were evaluated for Seed Yield Efficiency by computing the ratio of seed dry matter wt. to non-seed dry matter wt. and their resistance as the percentage of damage pods.

Preliminary data indicated that cultivars kim and Oakland (MG III), Kingston and Jefferson (MG IV), Pershing and PI 416.467 (MG V) were very high in SYE while Fuji (MG III), Sanga (MG IV) and PI 417.266 (MG V) were observed to have high level of resistance to *Heliothis* Zea.

We hope that these cultivars could be used as parents for the development of Breeding Program in Vegetable Soybean.

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#### BREEDING STRATEGIES FOR DEVELOPING DRY BEAN CULTIVARS RESISTANT TO BRUCHID WEEVILS

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The presence of arcelin protein in the seeds of common bean, *Phaseolus vulgaris* L., provides resistance to the Mexican bean weevil and to a lesser degree, the common bean weevil. Fast, accurate identification of single seeds containing arcelin facilitates the transfer of alleles for each of four different arcelin types through standard crossing procedures. Seed yields and other traits of near-isogenic lines that contain different alleles were comparable to the standard parent, Porcillo 70. Genotypic mixtures containing resistant and susceptible seeds produced seed yields comparable to Porcillo 70, which suggests that heterogeneous populations offer the potential for stable resistant cultivars.

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#### DEVELOPMENT OF MULTIPLE-DISEASE-RESISTANT PLUM CULTIVARS

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Plum production in the Southeastern United States is limited because cultivars are susceptible to bacterial canker (*Pseudomonas syringae*), bacterial fruit and leaf spot (*Xanthomonas pruni*), black knot (*Apisorina morbosa*) and plum leaf scald (*Xylella fastidiosa*). Evaluation of four new cultivars developed by the Alabama Agricultural Experiment Station indicated that AU-Rubrum, AU-Rosa and AU-Cherry were resistant to all the diseases listed, and AU-Amber was resistant to all except A. morbosa. Disease ratings were made on trees in six experimental plantings in Alabama, in Georgia test plantings and in grower trials.

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#### ASSAYS TO DETERMINE CHERRY ROOTSTOCK TOLERANCE TO "BACTERIAL CANKER" (*PSEUDOMONAS SYRINGAE* PV. *SYRINGAE*)

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An excised twig assay was developed to evaluate cherry genotypes for their tolerance to *Pseudomonas syringae* pv. *syringae*. One-year-old wood was collected at monthly intervals from Oct. until Jan. of 'Napoleon', 'Corum', and a number of cherry rootstock. The rootstock included F/12-1, Giessen (GI), and MxM selections. Twigs were inoculated with one avirulent and three virulent strains. Evaluation of incision browning, callus, and gummosis production were made after incubation for 3 weeks. Based on gummosis and browning ratings, all the rootstocks tested were found to be more tolerant than 'Napoleon' and 'Corum' to the 3 strains of *Pseudomonas syringae* used. No gummosis or browning was observed on twigs inoculated with water or the avirulent strain.

Plant signals extracted from cherry leaves have been shown to control expression of virulence genes in *P. syringae*. Crude aqueous extracts from 'Napoleon' twigs induced the *syb::lacZ* fusion in *P. syringae* strain B3AR132. Other rootstocks are currently being evaluated for their ability to induce virulence in *P. syringae* pv. *syringae*.

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## 42 ORAL SESSION (Abstr. 430-437) CROSS-COMMODITY: TISSUE CULTURE II

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430

#### IN VITRO PROPAGATION OF ALGERIAN IVY (HEDERA CANARIENSIS L.)

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Shoot tip explants of Algerian Ivy *Hedera canariensis* were cultured on MS basal medium supplemented with a combination of salt strength and NAA and IBA. More roots per explant developed on full salt strength medium combined with NAA. The

most roots per explant were obtained with a combination of IBA and 1/4 MS salt. There was an inverse relationship between an increase in IBA or NAA concentration and root length and number. Shoots proliferated better on full MS salt combined with NAA and IBA. The highest level of NAA (40  $\mu$ M) and 0.1  $\mu$ M TDZ produced the most shoots and roots, the longest roots, the highest rooting percentage, the largest plants with the most leaves and the best callus quality per explant. The leaves from in vitro were cultured on MS medium with varying levels of Thidiazuron (TDZ) and NAA in the presence of light produced the highest number of roots.

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SEED EXPLANT MATURITY AND 2,4-D AFFECT ORGANOGENESIS OF WHITE ASH (*FRAXINUS AMERICANA* L.) Sharon Bates\* and John E. Preece., Department of Plant and Soil Science, Southern Illinois University, Carbondale, IL 62901

At three different times throughout the growing season, white ash seeds representing different maturity levels were transversely dissected, surface sterilized, and placed on agar-solidified MS medium containing 10  $\mu$ M thidiazuron (TDZ) and a factorial combination of 0, 1, and 5  $\mu$ M 2,4-D and 0, 0.5, and 1  $\mu$ M glyphosate. After four weeks, explants were transferred to MS medium containing 5  $\mu$ M BA and 5  $\mu$ M NAA. After 12 weeks in vitro, the greatest percent (60%) of explants with organogenesis (adventitiously produced leafy structures that could grow into shoots) was when seeds were exposed to 1  $\mu$ M 2,4-D. Organogenesis occurred on explants only exposed to TDZ (31%), therefore auxin was not necessary for, but enhanced organogenesis. Seed explants were not consistently stimulated, or inhibited by these levels of glyphosate. Compared to immature-seeds, mature seed explants were the most organogenic (67%) and had the greatest amount of adventitious shoots (14%).

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THE INFLUENCE OF pH ON AUXIN-INDUCED ADVENTITIOUS ROOT INITIATION IN *MALUS DOMESTICA*

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Many physiological responses in plants are influenced by pH. The present chemiosmotic hypothesis suggests that auxin uptake into plant cells is governed by pH. Since auxin is used widely to enhance rooting, the influence of pH on 1H-indole-3-butyric acid (IBA) induced adventitious root formation was examined. Roots were initiated aseptically in 5 node apical shoot cuttings of micropropagated *Malus domestica* 'Gala'. Initiation was induced using a four day pulse in IBA and 15 g/L sucrose at pH 5.6 and 30C in the dark. Observations showed pH rose to 7.0 or greater within 1 to 2 days from microcutting placement in unbuffered initiation medium. Root numbers from shoots in media containing 1.5  $\mu$ M IBA buffered with 10 mM 2[N-morpholino] ethanesulfonic acid (MES) to pH 5.5, 6.0, 6.5 or 7.0 with KOH resulted in average root numbers of 14.2, 10.9, 8.7, and 7.1, respectively, while unbuffered medium yielded 7.6 roots per shoot. Comparison of MES buffered medium at pH 5.5, 6.25 or 7.0 in factorial combination with IBA at 0, 0.15, 1.5, 15.0, and 150.0  $\mu$ M resulted in a significant pH by IBA interaction for root number. At 0, 0.15 and 1.5  $\mu$ M IBA root numbers were greatest at pH 5.5. At 15.0  $\mu$ M IBA, pH 6.25 was optimal and at 150.0  $\mu$ M IBA all three pH levels produced equivalent root numbers. A calorimetric assay to measure IBA removal from the initiation medium by microcuttings of 'Gala' and 'Triple Red Delicious' showed more IBA removal at pH 5.5 than at pH 7.0. Possible reasons for the effect of pH on adventitious root formation will be discussed.

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MICROPROPAGATION OF SELECTED DESERT-ADAPTED SPECIES Dao-Shun Huang, Jingkun Ho and Ralph Backhaus\*, Department of Botany, Arizona State University, Tempe, Arizona 85287

Tissue culture methods have been developed for a number of desert-adapted species which have potential economic value. These species include gum tragacanth (*Astragalus gossypinus*), candelilla (*Euphorbia antisiphilitica*), guayule (*Parthenium argentatum*), cliff rose (*Cowania stansburiana* and *C. subintegra*), bottle tree (*Brachychiton populneum*), red squill (*Urginea maritima*), Arizona agave (*Agave arizonica*), and spider lily (*Pancratium littorale*). Axillary shoot proliferation for the dicotyledonous species of this group is induced using concentrations of 2 mg/L BAP, whereas the

rooting requirements vary considerably. Micropropagation of the bulb-producing species, is accomplished by aseptic culture of bulb scales in darkness, followed by shoot proliferation of the bulblets and rooting. Micropropagation of Agave requires adventitious shoot formation from a callus intermediate followed by direct caulogenesis from subculture shoots and subsequent rooting.

The potential benefit of these desert-adapted species and the usefulness of the micropropagation procedures will be discussed.

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PRE-FORCING TREATMENTS AND PLANT GROWTH REGULATORS IN THE FORCING SOLUTION PROMOTE MACRO- AND MICRO-PROPAGATION OF WOODY PLANT SPECIES

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BA, IBA and GA, were incorporated into softwood tissues to be cultured in vitro or rooted as cuttings by adding the plant growth regulators (PGR) at various concentrations to a forcing solution containing 200 mg/l 8-hydroxyquinoline citrate and 2% sucrose. BA and GA, helped break bud dormancy in autumn-collected stems and increased percent bud-break. IBA inhibited bud break and shoot elongation. Rooting of forced softwood cuttings was enhanced by IBA in the forcing solution, while GA, inhibited the rooting of plant species tested. When dormant stems were forced with periodic additions of BA (10 mg/l) in the forcing solution, in vitro shoot proliferation was enhanced. However, inclusion of GA, in the forcing solution reduced shoot proliferation. A pre-forcing NaOCl soak and a pre-forcing treatment with wetting agents accelerated bud break, size and number of shoots available for both micro- and macro-propagation of the woody plant species tested. The forcing solution protocol described is an effective PGR delivery system and it can be used by the propagator to extend the season for obtaining softwood growth suitable for use as in vitro explants or softwood cuttings.

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USE OF FORCING SOLUTIONS TO STUDY PLANT GROWTH REGULATOR EFFECTS ON VANHOUTTE'S SPIRAEA CULTURED IN VITRO

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Vanhoutte's spiraea has been propagated in vitro using explants from softwood growth of dormant stems forced in a solution containing 200 mg/l 8-hydroxyquinoline citrate (8-HQC) and 2% sucrose (Yang and Read, 1989). Objectives to further utilize this system were to determine the feasibility of applying plant growth regulators (PGR) via the forcing solution to softwood growth from forced dormant stems and to study the resulting influence on in vitro culture. BA and GA, were placed in the forcing solution at various concentrations, including a zero PGR control. Explants were cultured on Linsmaier and Skoog (LS) medium containing zero PGR or different amounts of BA or thidiazuron (TDZ) or combinations of BA and IAA. Control explants placed on LS medium supplemented with 5  $\mu$ M BA with or without 1 or 5  $\mu$ M IAA, or with 0.5 or 0.75  $\mu$ M TDZ alone produced the best shoot proliferation. BA in the forcing solution stimulated micropropagation, while GA caused less proliferation than explants from control solutions. Forcing solutions containing PGR are useful for manipulating responses of plant tissues cultured in vitro and for studying PGR influence on woody plant physiology.

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CLONAL MICROPROPAGATION OF MALE-STERILE ZINNIA ELEGANS R.B. Rogers\*, M.A.L. Smith, and R. Cowen, Department of Horticulture, University of Illinois, Urbana, IL 61801

The only method for large scale production of pure hybrid seed in *Zinnia elegans* involves the use of male sterile individuals. The male sterile trait, however, is a three gene recessive which at best produces only 50% male sterile progeny from seed. Since no method of clonal propagation is available, seed-produced female lines require labor intensive field roguing to insure removal of all normal flowered individuals. Clonal micropropagation was investigated as a means of mass producing male steriles for use as female lines. Sterilization procedures were developed for seed and axillary bud explants. Shoot proliferation media containing various levels of BAP, 2ip, and kinetin were screened using in vitro germinated seedling explants of the inbred line 'Orange Starlight'. Microshoots demonstrated a high rooting percentage after 2 weeks on basal medium without growth regulators. Plantlets were easily acclimated in 1 to 2 weeks in a high humidity environment. In vitro derived plants of identified male sterile plants were phenotypically evaluated as to their suitability for use in field production.

# OSMOTIC ADJUSTMENT AND GROWTH RESPONSE OF THREE *in vitro* GROWN *Chrysanthemum morifolium* Ramat. CULTIVARS TO OSMOTIC STRESS.

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Osmotic adjustment in response to decreasing media water availability was observed for *in vitro* *Chrysanthemum morifolium* Ramat. cultivars Bright Golden Anne, Deep Luv, and Lucido. Water stress was induced by increasing sorbitol (0, 0.1, 0.2, 0.3, 0.4 M), mannitol (0, 0.1, 0.2, 0.3, 0.4 M), and sucrose (30, 45, 60, 75, 90  $\text{g} \cdot \text{L}^{-1}$ ) concentrations in modified MS media (2  $\text{mg} \cdot \text{L}^{-1}$  BA and 0.1  $\text{mg} \cdot \text{L}^{-1}$  NAA). Osmotic adjustment was evidenced by a significant reduction in measured cell sap osmotic potential ( $R^2 = 0.78$ , 0.96, 0.91 for sucrose, sorbitol, and mannitol respectively) in all cultivars. Shoot length, weighted density (apparent mass), and proliferation were significantly reduced by sorbitol and mannitol treatments. Sucrose reduced shoot proliferation, increased length, and had an inconsistent effect on weighted density. Cultures grown on media without hormones showed tremendous increase in root number up to 60  $\text{g} \cdot \text{L}^{-1}$  sucrose. Sorbitol had a negligible effect on rooting at 0.1 M but no roots developed at higher sorbitol concentrations or in any mannitol treatments. Plants transferred to a non-water-stress media after they had experienced *in vitro* water stress exhibited no change in osmotic properties from the stress treatments.

# EFFECT OF GROWTH-REGULATING SUBSTANCES ON GROWTH OF HIBISCUS TREATED WITH UNICONAZOLE

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*Hibiscus rosa-sinensis* 'Jane Cowl' were pruned several weeks after receiving 0.1 mg/pot uniconazole soil drenches to retard the growth. Plants then received foliar sprays of  $\text{GA}_3$  (50 ppm), KIBA (200 ppm), or PBA (200 ppm) immediately after pruning or when the lateral shoots had three leaves. Application of the above growth regulators immediately after pruning had no effect on plant growth. When treatments were delayed until the three-leaf stage,  $\text{GA}_3$  completely restored leaf production rate and partially restored shoot elongation and pedicel length.  $\text{GA}_3$  also increased leaf area, and the leaf specific weight was similar to leaves on plants not receiving uniconazole.  $\text{GA}_3$  increased flower production 175% and 65% more than plants treated with uniconazole and the untreated plants, respectively. KIBA and PBA had no effect on altering the growth of uniconazole-treated plants. Foliar application of a combination of  $\text{GA}_3$ , KIBA and PBA at the three-leaf stage had an effect similar to that of  $\text{GA}_3$  alone. However, the effect of  $\text{GA}_3$  on growth appeared to be transient and repeated application may be required to maintain the restored growth of uniconazole-treated plants.

# PLANT GROWTH MODIFICATION AND WATER USE OF HIBISCUS ROSA-SINENSIS 'BRILLIANT' PLANTS BY UNICONAZOLE WITH VARIOUS COMBINATIONS OF PLANT GROWTH REGULATORS.

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Various uniconazole (Sumagic™) rates were either sprayed or drenched alone or in combination with 6-BA and  $\text{GA}_{4+7}$  (Promalin™) or dikegulac-sodium (Atrinal™) on *Hibiscus rosa-sinensis* 'Brilliant'. The rates of uniconazole were 0, 5, 10, and 15 mg a.i./L; 6-BA and  $\text{GA}_{4+7}$ , 25 mg a.i./L each; and dikegulac-sodium 1000 mg a.i./L.

Plant height was reduced by uniconazole when drenched at rates as low as 5 mg/L and 15 mg/L when sprayed. Dikegulac-sodium slightly counteracted the effects of uniconazole. Uniconazole activity was increased when either sprayed or drenched with application of 6-BA and  $\text{GA}_{4+7}$ , resulting in greater height reduction.

Transpiration and stomatal diffusive resistance of plants drenched with uniconazole alone was erratic; however, when uniconazole was sprayed or drenched and mixed with 6-BA and  $\text{GA}_{4+7}$  or dikegulac-sodium transpiration increased.

# COMPARISON OF THE EFFECT OF PRUNING AND CHEMICAL GROWTH REGULATION ON THE WATER RELATIONS OF HIBISCUS

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Growth of potted hibiscus (*Hibiscus rosa-sinensis* Ross Estey) plants was controlled by either pruning or the growth regulator, uniconazole, at 3.0 mg a.i. per pot. Five days after treatment with uniconazole, plants showed reduced water use, an effect which became more pronounced with time. Water use of pruned plants was reduced immediately after pruning, but soon returned to the level of the control due to the rapid regeneration of leaf area. Chemically treated and pruned plants, respectively, used 33% and 6% less water than the control. The reduction in water use due to the use of uniconazole had both a morphological and physiological component. Chemically treated plants had a smaller leaf area, and individual leaves had a lower stomatal density, conductance and transpiration rate than leaves of control plants. Under well watered conditions, the sap flow rate in the main trunk of control or pruned plants was 120-160  $\text{g} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$ , nearly three times higher than the 40-60  $\text{g} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$  measured in plants treated with uniconazole.

# LONG-TERM CONTROL OF TREE GROWTH IN UTILITY RIGHTS OF WAY USING GROWTH REGULATORS

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

Twelve to 15 year old silver maple and wild cherry trees were top pruned severely to a height of 5m and then trunk injected with Prunit 20g/l at 0, 0.1, 0.5 or 1.0 g/inch of trunk diameter or were

## 43 ORAL SESSION (Abstr. 438-444) WOODY PLANT GROWTH REGULATION

### GROWTH ENHANCEMENT OF PHOTINIA X FRASERI WITH FOLIAR APPLICATIONS OF GROWTH REGULATORS

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The action of foliar-applied uniconazole, paclobutrazol, dikegulac-sodium, ancymidol, 6-BA,  $\text{GA}_{4+7}$ , and 6-BA +  $\text{GA}_{4+7}$  on container-grown Photinia x fraseri was studied over a one year period. Vegetative growth habit was evaluated at three month intervals. Shoot dry weight and histological examination of stem anatomy in the apical meristematic region was conducted at experiment termination.

Several plant growth regulators, primarily uniconazole, 6-BA, 6-BA +  $\text{GA}_{4+7}$ , and dikegulac-sodium, stimulated lateral branching. Linear increases in lateral branching occurred as application rates increased. High application rates of uniconazole and paclobutrazol created an asymmetrical growth habit and decreased dry weight accumulation.

### EFFECTS OF UNICONAZOLE MEDIA DRENCH AND FOLIAR SPRAY APPLICATIONS ON GROWTH OF PYRACANTHA, PHOTINIA, AND DWARF BURFORD HOLLY

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Uniform liners of pyracantha (*Pyracantha coccinea* Roem 'Lalandei'), photinia (*Photinia x fraseri* Dress) and dwarf Burford holly (*Ilex cornuta* Lindl. and Paxt. 'Burfordii Nana') were potted into 3.8 liter containers in a pine bark:sand medium. Ten weeks later, plants received uniconazole treatments as a media drench or foliar spray. The uniconazole drench rates were 0, 0.5, 1.0, and 3.0 mg ai per container for all three plant species. The foliar application rates were 0, 50, 100 and 150 ppm for pyracantha, 0, 25, 50 and 100 ppm for photinia, and 0, 10, 25, and 50 ppm for dwarf Burford belly. Plant heights and widths were recorded at 3 week intervals, and leaf chlorophyll content was determined by calorimeter at the same time as height and weight measurements. At harvest, leaf counts, leaf areas, and shoot, leaf and root dry weights were determined. Initial results indicate that both foliar and media drench treatments of uniconazole reduced growth of pyracantha and photinia at all rates. Only the two highest rates decreased growth of dwarf Burford holly when applied as either a media drench or a foliar spray.

treated with a trunk pour of Prunit 50W at the rate of 0, 0.5 or 1.0 g/inch of trunk diameter. Treatment effects were not obvious on any trees until 12 months after treatment. After 36 months maples receiving the two highest rates had made less than 50 cm of growth above the pruned top of the tree whereas the untreated control had produced 3 m of new shoot growth. The 0.1 g rate produced less aesthetic disruption to the appearance of the tree and reduced growth to 1.2 m. Wild cherry trees responded similarly but the amount of regrowth following pruning was less. Maple trees receiving the trunk pour treatment exhibited a 50% reduction in new shoot growth 36 months after treatment.

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#### STOCKPLANT ETIOLATION, SHADING, AND STEM BANDING EFFECTS ON THE AUXIN DOSE-RESPONSE OF ROOTING IN SOFTWOOD STEM CUTTINGS OF CARPINUS BETULUS 'FASTIGIATA'.

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Three experiments were undertaken to examine the effect of stockplant etiolation, shading, and stem banding, prior to cutting propagation, on the auxin dose-response of rooting in stem cuttings of *Carpinus betulus* 'fastigiata'. A  $2 \times 2$  factorial of etiolation and banding utilized stockplants forced in a greenhouse, etiolated for 1 week and banded with Velcro™ for 1 month. In a separate study shading was applied up the time of harvesting cuttings. IBA was applied to cuttings as an aqueous ethanol quick dip in concentrations ranging from 0 to 80 mM. Rooting percentage and number were best described, up to a peak response, by a linear function proportional to the logarithm of applied IBA. The inhibition of rooting by supra-optimal IBA was directly proportional to IBA concentration. Cuttings prepared from shoots which had been etiolated or banded rooted better at low IBA and at their respective optimal IBA levels. Cuttings from shoots receiving both etiolation and banding yielded higher rooting percentages and more roots per rooted cutting on average. Etiolation and banding served to increase both initial and maximum rooting capacities, and to reduce the sensitivity of cuttings to supraoptimal auxin-induced inhibition of adventitious root initiation. The auxin dose-response interacted with shading to yield the best rooting at 95% shade and 3.7 mM IBA.

## 44 ORAL SESSION (Abstr. 445-449) CROSS-COMMODITY EDUCATION

445

#### A HANDS-ON GRADUATE EXERCISE IN HORTICULTURAL PLANT AND ENVIRONMENTAL RESEARCH METHODS

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Horticulture Research Methodology courses are an important if not essential introduction to research for beginning graduate students. Such courses are often characterized by presentation of a series of experimental techniques, lacking continuity and out of context with real-world research situations. In the described course, students gained expertise with a range of environmental and plant measurement techniques within the framework of a semester-long experiment. The experimental techniques were introduced and incorporated into the experiment at appropriate stages. Each student engaged in hands-on participation in development of a proposal; experimental set up, implementation, and daily maintenance; and data accumulation, analysis, and reporting (in *HortScience* manuscript format). In addition to direct experience with all subject techniques, each student had individual responsibility for characterization of a selected plant (or environmental) parameter. This format successfully accomplished the provision of direct and coherent experience with a wide variety of important horticultural research techniques within a real-world setting.

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#### BRIDGING THE GAP: EDUCATION TO EMPLOYMENT

Cynthia L. Baker\*, Chicago Botanic Garden, Glencoe IL 60022

With the growing emphasis on research and a continuous crunch for space, practical "lab" training available for many students is scarce or declining. Though our horticulture

graduates are quite knowledgeable, their "hands-on" experience is often very limited. This places them at the bottom of the job ladder even though they have been educated for more advanced positions. It's difficult to recruit students into 4-year degree programs when starting salary is barely above that of a high school graduate. We can enhance the students marketability through experiential education by tapping the resources of the horticultural industry before they graduate. Through internships and 'co-op' students get the practical training and experience they need to qualify for better paying and more challenging jobs. It's an old concept, but one that is underutilized by both students and advisors.

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#### JOHN H. PATTERSON'S USE OF HORTICULTURE FOR INDUSTRIAL WELFARE IN THE EARLY 1900'S

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John H. Patterson, founder and president of the National Cash Register Co. (now NCR Corp.), is best known for his innovative business practices which made the cash register a standard product. Less well-known was his program of industrial welfare for NCR employees which included many uses of horticulture. Illustrations of the landscaping contests Patterson sponsored in his factory neighborhoods are shown in a collection of early 1900's glass lantern slides recently discovered in the University of Maryland Horticulture Building attic. The noted Olmsted landscaping firm was hired to design the NCR factory grounds. Neighborhood children were given company land, tools, instructions, and awards, enabling them to grow vegetables to sell and to give to their families. Patterson created these 'Boys Gardens' to occupy youngsters who might otherwise break windows in the NCR factory and give the factory neighborhood a bad reputation. Although his program of industrial welfare was unique in an era of worker exploitation, Patterson justified the program because "It pays".

448

#### DEVELOPING ENVIRONMENTAL AWARENESS WITH YOUNG PEOPLE Karen Stoelzle Midden, Plant and Soil Science, Southern Illinois University, Carbondale, IL 62901

Developing public awareness of the intricate relationship between people and their environment is critical to effectively deal with the increasing demands of population growth and man's ability to manipulate the environment. A holistic and practical understanding of these concerns should be introduced to young people. Evaluations of an environmental gaming/simulation for young people indicate that it offers a creative method of heightening awareness and insights into the value of master planning. This gaming/simulation (EGS) simulates the development of a subdivision in which the participants are the planners. Each participant assumes a different role with differing interest, but they must work together as decision-makers. EGS does not give the "correct" answers to living in an environmentally perfect world. It is simply a tool to increase the participants awareness of environmental concerns, to teach the value of planning, exploring alternatives, and to give an understanding of the relationships between the elements in the game.

449

#### DRAWING AS A MEANS OF ALTERNATIVE EDUCATION IN PUBLIC BOTANICAL GARDENS

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Increased interest in nature over the past three decades has generated a need for better educational programming in public botanical gardens. The purpose of this study was to develop stronger educational programming for public botanical gardens. Garden programs which have been most successful are those which incorporate interaction and the multi-media. Eight different programs, which conveyed the same information, were developed to test the impact of drawing on learning. The 240 volunteers observed six native plant either in the field or as slides in the classroom. A  $3 \times 4$  Factorial Manova was used to evaluate if drawing had any effect on learning. It was concluded that drawing alone improves learning by 12.37%.



## 45 ORAL SESSION (Abstr. 450-456) CROSS-COMMODITY POSTHARVEST PHYSIOLOGY I

450

### POSTHARVEST QUALITY CHANGES IN RADICCHIO

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Radichio, also known as red-leaved chicory (*Cichorium intybus* L.), is a high value vegetable crop. Few postharvest characteristics have been described for this crop. Five cultivars of radichio were held at 1 and 10°C in plastic boxes or shrink-wrap bags to determine postharvest quality changes. Weight loss was similar at both temperatures for all cultivars. Major quality losses of radichio held in shrink-wrap or plastic boxes at 1°C were caused by leaf browning. Shrink-wrapping prevented leaf shrinkage and bleaching, but enhanced decay at 10°C. The respiration rate of radichio heads held at 1°C was initially 7.4 ml C O<sub>2</sub> g<sup>-1</sup> h<sup>-1</sup>, then fell to 3 ml CO<sub>2</sub> kg<sup>-1</sup> h<sup>-1</sup> after 7 days of storage at 1°C. Respiration at 10°C was maintained near 19 ml kg<sup>-1</sup> h<sup>-1</sup> through the duration of the experiment. Shrink-wrapped radichio held at 1°C had marketable quality for 5 weeks.

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### EFFECT OF CA STORAGE ON THE ULTRASTRUCTURE OF CHLOROPLAST AND CHLOROPHYLL CONTENT OF CHINESE MUSTARD

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A study of the ultrastructure of leaf tissues of Chinese mustard shows that there is a progressive degeneration of the membrane structure of the grana of the chloroplast accompanied with the appearance of globules of lipid material and loss of chlorophyll during leaf senescence. A controlled atmosphere of 5% CO<sub>2</sub> plus 3% O<sub>2</sub> maintained chloroplast grana membrane structure for up to 4 weeks storage at 10°C. Both 5% CO<sub>2</sub> (in air) and 5% CO<sub>2</sub> plus 3% O<sub>2</sub> maintained the highest chlorophyll content compared to 3% O<sub>2</sub> alone or in air (control).

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### EFFECT OF TIME/TEMPERATURE TREATMENTS ON PHENYLALANINE AMMONIA-LYASE ACTIVITY AND DEVELOPMENT OF RUSSET SPOTTING IN ICEBERG LETTUCE

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Russet spotting (RS) is an important postharvest disorder in Iceberg lettuce (*Lactuca sativa* L.). Previous studies showed that RS is induced by exposure to ~5 ppm (ul/l) ethylene at ~5°C for 3 days and is characterized by the appearance of 1 to 2 mm diam. oval, brown sunken spots along the midrib. Increases in phenylalanine ammonia-lyase (PAL) activity and phenolic content are highly correlated with RS development. Ethylene-induced PAL activity is much less at higher (12°C) or lower (0°C) temperatures. In this study isolated whole leaves were exposed to a log series of ethylene concentrations from 0.1 to 10 ppm at temperatures from 0.0°C to 20°C for up to 8 days. Tissue was transferred among these various treatments to investigate the kinetics of PAL induction, activity and deactivation, phenolic accumulation, and RS development. A subjective evaluation was then made of RS development using a 1 to 9 scoring system in which 1 was no RS, and then PAL activity and phenolic content were measured. Preliminary results indicate that ethylene-induced PAL activity was decreased more rapidly upon transfer to temperatures above 10°C than to 0.0°C. Accumulation of phenolic compounds and development of RS paralleled each other, and were positively related to PAL activity. Practical implications of these results will be discussed.

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### 3-AMINO-1,2,4-TRIAZOLE, A CATALASE INHIBITOR, PROLONGS CARNATION VASE LIFE.

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Sim-type carnation flowers (*Dianthus caryophyllus* L., cv. Elliot's White) continuously treated with 50 mM or 100 mM 3-amino-1,2,4-triazole (amitrole) and held in the dark at 18°C did not exhibit a respiratory climacteric relative to dH<sub>2</sub>O-treated controls. No morphological changes symptomatic of floral senescence appeared in treated flowers until 12-15 days post-harvest. Other triazoles were not effective in prolonging senescence. Amitrole appears to inhibit

ethylene biosynthesis by blocking the enzyme-mediated conversion of S-adenosyl-L-methionine to 1-aminocyclopropane-1-carboxylate.

Ethylene action appears to be progressively inhibited in that flowers held in treatment solution for 2 d or less responded to application of 10 uL/L exogenous ethylene whereas flowers held 10 d or longer exhibited no response. Electrophoretic resolution of total crude extracts evidenced protein synthesis as well as degradation. Western analysis and total activity assays showed an amitrole concentration-specific inhibition of catalase activity.

455

### EVIDENCE AND POSSIBLE MECHANISMS FOR MEMBRANE DETERIORATION DURING LONG-TERM STORAGE OF POTATO

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Studies on the mechanisms by which growth potential of potato seed-tubers declines during aging suggest that membrane deterioration may be involved. Malondialdehyde (MDA) content, ethane evolution, solute leakage, and activity of the membrane-bound ethylene forming enzyme (EFE) were measured in tissues from 2, 14 and 26-month-old potato tubers as potential indicators of peroxidative damage and loss in membrane integrity. Solute leakage increased with tissue age, reflecting loss in membrane integrity. MDA content, a measure of lipid peroxidation, also increased with tuber age. Ethane is a product of free-radical-mediated peroxidation of polyunsaturated fatty acids (PUFA), and is therefore a sensitive marker of membrane damage. In the absence of fatty acid substrate, old tissue evolved less ethane than young tissue. However, addition of linoleate to the incubation medium stimulated more ethane from the oldest tissue, indicating a higher potential for ethane production. In vivo conversion of ACC to ethylene by EFE declined with age, possibly due to membrane deterioration. These studies show that peroxidation of PUFA may be influencing membrane integrity during long-term storage of potato.

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### EFFECTS OF LOW-TEMPERATURE ON THE QUALITY OF TURNIP ROOTS

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The influence of low-temperature on the starch, sugar and glucosinolate content was studied in the mature roots of field and greenhouse-grown turnip. A decrease in both starch and sugar levels was recorded in roots after storage at 0°C for 4 weeks. On the other hand, when plants were exposed to a series of cold treatments, the starch level remained constant but the level of sugars increased in roots. In our studies, turnip roots exhibited the capacity to synthesize and degrade specific glucosinolates at low temperatures. The implications of these findings on the sensory characteristics of the root will be discussed.

## 73 ORAL SESSION (Abstr. 457-464) FRUIT CROPS: GROWTH AND DEVELOPMENT II

457

### CHILLING ENHANCEMENT OF ROOT REGENERATION IN APPLE CAN OCCUR WITHOUT BUDBREAK OR GROWTH OF ROOT SUCKERS

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After receiving 0, 600, 1200, or 1800 hr. of chilling at 5°C, one-year-old *Malus domestica* Borkh. seedlings were given 10 sec. root dips either 10,000 ppm K-IBA solution or water control. Following chilling and IBA treatments, 20 seedlings of each combination were placed in forcing conditions of 20 ± 2°C root temperatures and either 20 or 5 ± 1°C shoot temperatures. Five seedlings of each treatment were harvested after 0, 7, 14, and 21 days of forcing. Five C prohibited budbreak and bark slippage for up to 21 days. Under 20°C, budbreak, shoot elongation and root growth all occurred earlier, faster, and reached a higher level with increased chilling. Twenty C root and 5°C shoot temperatures during forcing resulted in large increases in the growth of adventitious shoots on lateral roots, but had little effect on the formation of adventitious shoots on the tap root. K-IBA prohibited development of adventitious shoots on roots,

reduced shoot elongation more so than budbreak, and increased root regeneration across chilling hours. K-IBA inhibition of adventitious shoots did not alter the overall pattern of root regeneration enhancement by chilling.

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#### TIME OF FRUIT REMOVAL INFLUENCES RETURN BLOOM IN PECAN

William Reid\*, Pecan Experiment Field, Kansas State University, P.O. Box 247, Chetopa, KS 67336-0247.

Pecan trees, *Carya illinoensis*, often exhibit a strong alternate bearing pattern. The presence of a heavy seed crop inhibits terminals from fruiting the following season. This study was developed to discover at what point in the development of the pecan fruit does this inhibition take place. Six nut removal times were evaluated: (1) after pollination but before fertilization, (2) one-half ovule expansion, (3) full ovule expansion or water stage, (4) dough stage, (5) 3 weeks after the initiation of the dough stage, and (6) no fruit removal until harvest. The cultivar 'Mohawk' was used for this randomized block experiment.

Return bloom was significantly enhanced by the removal of fruit prior to the initiation of kernel filling (dough stage). Less than 10% of terminals that supported pecans through the dough stage were able to produce distillate flowers the following year. Twig mortality was significantly higher for terminals that completed kernel filling. These results indicate that nut thinning prior to the water stage may reduce the alternate bearing tendency in pecan.

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#### CALLUS FORMATION IN BUD UNIONS OF 'JONAGOLD' ON 'MARK' ROOTSTOCK

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'Mark' rootstock is a relatively new dwarfing rootstock that induces precocity in apple trees. While 'Mark' has desirable horticultural characteristics, it has been difficult to propagate in some areas of the United States. To determine the optimum budding date at two climatically diverse locations, 'Jonagold' buds were chip-budded onto 'Mark' rootstock on 20 July, 10 Aug., 31 Aug. and 21 Sept. 1989 at Atlas, Illinois and Wenatchee, Washington. Prior to budbreak, unions were sampled from each budding date and the callus, bud plate and rootstock were measured and photographed. Trees budded and grown in Illinois had more callus growth than those budded in Washington. In Illinois, the callus of trees budded on 20 July averaged 3.2 mm., whereas those budded on 21 Sept. averaged 1.0 mm. Trees grown in Washington had 0.4 mm of callus at both budding dates. Callus growth will be correlated with union compatibility and strength in Nov. 1990.

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#### APPLE TREE LIGHT INTERCEPTION, PHOTOSYNTHESIS, GROWTH, AND YIELD AS AFFECTED BY DIFFERENT ROOTSTOCKS

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Mature apple (*Malus domestica* Borkh.) trees with "Starkspur Supreme Delicious" as the scion grafted on nine different rootstocks were studied in 1987 and 1988. Canopy seasonal development and its light interception were examined using fisheye (hemispherical) photographs. Rootstock affected the amount of structural wood, the rate of canopy development and the final leaf area. However, rootstock did not affect the sigmoidal pattern of canopy development. Photosynthesis (Pn) was measured under field conditions. Shoot leaves, spur leaves on spurs without fruits (S-F), and spur leaves on spurs with fruit (S+F) from trees on M.26 EMLA and OAR 1 showed no differences in Pn rates. However, for both rootstock, shoot leaves had the highest Pn rate, S-F the lowest, and S-F leaves had intermediate values. Growth and yield components were assessed by leaf separation into shoot and spur leaves while harvesting them. Rootstock strongly affected the canopy leaf distribution as well as leaf number, dry weight, area, number of spurs and yield PCLC. Yield efficiency was mainly dependent upon spur leaf dry weight. OAR 1 performed uniquely in this study.

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#### FLORAL-DERIVED VOLATILE COMPOUNDS: A ROLE IN POLLINATION?

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Volatile compounds, commonly produced by flowers during bloom, have been described as insect attractants. Some of these compounds stimulate *Pinus* pollen

germination *in vitro* (French et al., 1979, J. Agric. Fd. Chem., 27:184-187), suggesting that such compounds may do the same *in vivo*. Red Delicious apple pollen was germinated on agar in a simple, enclosed *in vitro* bioassay system in the presence of a number of plant tissues, including apple, tomato, and chrysanthemum leaves, apple flowers, rose petals, and apple fruit slices. These tissues represent a diversity of types of volatile compounds. Pollen germination was recorded by microphotography after 1 and 2 hours, and percent germination was determined. Although stimulation of germination was not observed, macerated tomato leaves inhibited it. To determine if the volatile characteristics of cultivars differ, flowers of Red Delicious and Golden Delicious apple were harvested at full bloom. Their volatiles were collected, identified, and quantitated by capillary GC-MS. Among 8 major compounds common in the two cultivars, several quantitative differences were observed. These results will be discussed in relation to the potential role of volatiles in pollen germination.

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#### COMPARISON OF SEASONAL RELATIVE GROWTH PATTERNS OF PEACH AND APPLE FRUITS AND THEIR NONSTRUCTURAL CARBOHYDRATE COMPOSITION

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The fruit growth of three peach (*Prunus persica* (L.) Batsch cvs. 'Spring Lady', 'Flamecrest', 'Cal Red') and two apple cultivars (*Malus domestica* Borkh. cvs. 'Cox Orange', 'Golden Delicious') was measured weekly during the 1988 growing period. Seasonal patterns of fruit relative growth rate calculated on a dry weight basis were very similar for both species. Changes in nonstructural carbohydrate composition of peach mesocarp and apple pericarp were correlated with the two physiological phases of sink-activity of the relative growth rates. Changes in sucrose concentrations seemed to coincide with increasing dry matter accumulation for both species, even though fructose was a dominant sugar in apples.

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#### ROOT DISTRIBUTION PATTERN OF NINE APPLE ROOTSTOCKS AT TWO NC-140 TRIAL LOCATIONS

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The 1980 NC-140 uniform apple rootstock trial plantings located in Michigan and Ohio were used to determine root distribution patterns of the nine rootstocks involved in the trial. The scion for the trial was Starkspur Supreme (*Malus domestica* Borkh.) on Ottawa 3, M.7 EMLA, M.9 EMLA, M.26 EMLA, M.27 EMLA, M.9, MAC 9, MAC 24 and OAR 1 rootstock. Trenches were established parallel with the tree rows 0.8 m from the center of the trunks on both sides. The trenches were 1.5 to 2 m deep. Grids were constructed 1.2 m deep x 1.8 m wide with 30 cm x 30 cm grid squares. Soil was washed from the profile and the grid was placed over the profile. Roots were classified into 3 size categories; less than 2 mm, 2 to 5 mm and greater than 5 mm. Soil physical properties were also characterized. Differences were found between rootstock root distribution patterns and will be discussed in relation to rootstock and location/soil properties.

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#### PRUNE OVULE LONGEVITY: EFFECT OF CULTIVAR AND FALL-APPLIED ETHEPHON

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Some cultivars of prune (i.e. 'Brooks') consistently set good crops while others (i.e. 'Italian') are erratic bearers. Fall-applied ethephon increases fruit set. Ovule longevity has been hypothesized to be an important factor in fruit retention. The effects of the cultivar and fall ethephon application on ovule longevity were determined.

Ethephon (0 and 500 mg·l<sup>-1</sup>) was applied to 'Italian' and 'Brooks' prune trees at the 50% leaf drop stage. The following spring, flower buds were emasculated and covered to prevent pollination. Ten flowers were sampled every two days from anthesis until 20 days after anthesis (DAA). Flowers were fixed in FAP and ovule longevity determined using fluorescence microscopy. Ovule longevity was longer in 'Brooks' than 'Italian'. At 20 DAA, all of the 'Brooks' flowers still had viable ovules. Only 40% of the 'Italian' flowers had viable ovules. The 'Italian' flowers excised from ethephon-treated trees had at least one non-senescent ovule at 17 DAA. Ethephon prolonged ovule longevity in 'Italian' prune flowers. No effect of ethephon was observed on the ovule longevity of the 'Brooks' prune.

## 74 ORAL SESSION (Abstr. 465-472) VEGETABLE CROPS: NUTRITION

465

### ELEMENTAL CONTENT IN TOMATO SEEDLINGS AS INFLUENCED BY PRE-TRANSPLANT CONDITIONING

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Processing tomato seedlings cultured in 288 cell plug trays were fertilized with solutions containing either 75-32-62 or 150-64-124 ppm N-P-K until the 4 to 5 true leaf stage (12 cm tall). At this developmental stage, the seedlings were nutrient conditioned with 0-0-0, 75-32-62, 150-64-124, 300-128-248 or 450-194-374 ppm N-P-K for up to 12 days. Within 3 days of initiation of pretransplant fertilization treatments, both the contents and mean concentrations in shoot tissue of total N, P, K and soluble  $\text{NO}_3$  were significantly altered. The maximum effects on tissue concentrations were observed within 5 days. Shoot growth rate of seedlings was affected within 5 to 8 days by a modification of elemental concentration within fertilizer solutions. The benefits of nutrient conditioning on tomato seedlings will be discussed.

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### POTASSIUM CHLORIDE CONCENTRATION DURING PRODUCTION AFFECTS TOMATO TRANSPLANT RESPONSE TO POSTPRODUCTION WATER STRESS

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Transplants of 'Ohio 8245' tomato grown in 48-cell plastic trays received 5 potassium chloride concentrations and were stressed by withholding water during the 6th week of growth. Gravimetric water loss differed between treatments with decreased water loss associated with increased potassium chloride concentration. As water was withheld, incidence of wilt was greater and more evident at an earlier stage with plants supplied with lowering KCL concentrations. Root and shoot dry weights, plant height and leaf area were not affected by treatments. This indicates an apparent increase in water use efficiency in tomato transplants supplied with KCL at greater concentrations than supplied under standard fertilizer regimes.

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### POTASSIUM SOURCE AND RATE AND CALCIUM RATE EFFECTS ON TOMATO YIELD AND QUALITY

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Tomatoes (*Lycopersicon esculentum* Mill.) were grown on a sand and loamy sand to evaluate the effects of K source, K rate, and Ca rate on plant nutrient uptake, fruit yield, and fruit quality. The K was applied at 200 and 400 kg  $\text{K-ha}^{-1}$  from KCl and  $\text{K}_2\text{SO}_4$ . Gypsum was applied at 0, 450 and 900 kg  $\text{Ca-ha}^{-1}$ . On the sand, tomato N leaf tissue concentrations were higher with  $\text{K}_2\text{SO}_4$  than KCl. Leaf K concentrations were higher and Ca contents were lower with the higher than lower K rate. At first fruit harvest, leaf Ca concentrations were linearly increased with an increase in Ca rate. Early and total fruit yields, however, were not influenced by K source, K rate, or Ca rate at both locations. Marketable fruit were more firm with  $\text{K}_2\text{SO}_4$  than KCl and with 200 than 400 kg  $\text{K-ha}^{-1}$  on the sand. Fruit were less firm on the sandy loam than sandy soil but was not affected by K source or rate on the former soil. Ca rate had no effect on fruit firmness on either soil. Fruit citric acid contents were higher with KCl than  $\text{K}_2\text{SO}_4$  and with 400 than 200 kg  $\text{K-ha}^{-1}$ . Fruit color and percentage dry weight were not affected by treatment.

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### EFFECT OF CULTIVAR AND NUTRIENT SOLUTION CALCIUM CONCENTRATION ON CALCIUM UPTAKE AND DISTRIBUTION IN COLLARDS

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'Vates' is more susceptible to tipburn than 'Blue Max' or 'Heavi Crop' when grown under high temperature conditions. Nutrient solution culture studies were conducted to determine the influence of cultivar and Ca level in

the nutrient solution on Ca uptake and distribution in the plant and to determine the physiological basis for differences in cultivar susceptibility to tipburn. Ca levels in the nutrient solution were 1 and 4.5 mM. Studies were conducted in the greenhouse at 32°C during the day and 21°C at night. Collard plants were 3 weeks old when the study was initiated. Cultivar and Ca level had no influence on Ca uptake during the first two weeks of the study. Ca uptake by 'Blue Max' was greater than by 'Vates' or 'Heavi Crop' during the 3rd, 4th and 5th weeks of the study. Ca uptake for 'Blue Max' was 73 ppm/week whereas for 'Vates' and 'Heavi Crop' it was 55 and 46 ppm/week, respectively during the 5th week of the study. Increasing the Ca level increased the Ca content of young leaves more for 'Blue Max' than for 'Vates' or 'Heavi Crop'. Ca content of the petiole and stem was higher for 'Blue Max' than for 'Vates' or 'Heavi Crop'. The influence of cultivar and nutrient solution Ca level on uptake and distribution of other nutrients will be discussed.

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### NITROGEN RATES FOR POTATOES-YIELDS AND TISSUE TESTS

Peter L. Minotti\*, Donald E. Halseth and Joseph B. Sieczka, Department of Vegetable Crops, Cornell University, Ithaca, N Y 14853

Experiments were conducted at Freeville, NY and Riverhead, NY with 0-280 kg/ha of N banded. Tissue samples (both petioles and whole leaves) were taken 5 times starting 32 days from planting. There was a marked increase in yield and specific gravity from the first 112 kg/ha of N and in most cases from an additional 56 kg/ha of N. Both petiole and whole leaf nitrate were sensitive to changes in fertilizer rate that resulted in yield changes. We were encouraged by results obtained with "quick" tests on fresh sap since the pattern paralleled that obtained with traditional lab analysis of dried ground petioles. Although nitrate concentrations did not vary markedly across the varieties used there were substantial differences due to location even when the yield response curve was similar. Rate of N for rate of N, the Freeville samples were substantially higher in nitrate than those from Long Island, except at the 0 N rate, suggesting that the difference is not due to soil residual N.

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### NUTRIENT CONCENTRATIONS IN SOIL SOLUTIONS FOR MUSKMELONS AS INFLUENCED BY FERTILIZER TREATMENT

Gerald E. Wilcox\*, Paul R. Adler and Mohamad Errebhi, Hort Dept, Purdue University, W. Lafayette, IN 47907

A study was made to investigate the effects of liming and N source fertilization on soil acidity, nutrient uptake and yield of muskmelon on a Princeton loamy-sand (fine sandy, mixed, mesic, type Hapludalf) at Southwest Purdue Agricultural Center, Vincennes, IN. The experiment consisted of lime and no lime treatments with five N treatments of 0 N, 50 kg  $\text{N-ha}^{-1}$  as urea and 100 kg  $\text{N-ha}^{-1}$  as urea,  $\text{NH}_4\text{NO}_3$ , and  $(\text{NH}_4)_2\text{SO}_4$ . The unlimed soil tested pH 4.6, 4.2 and 4.1 and the limed soil was pH 5.5, 5.6 and 5.2 with 100 kg  $\text{N-ha}^{-1}$  as urea,  $\text{NH}_4\text{NO}_3$ , and  $(\text{NH}_4)_2\text{SO}_4$ , respectively. With  $\text{NH}_4\text{NO}_3$  the  $\text{NO}_3\text{-N}$  declined from 268 ppm on 6/1 to 64 ppm on 7/7 in the saturation extract (SE). Highest  $\text{NH}_4\text{-N}$  was from  $(\text{NH}_4)_2\text{SO}_4$  followed by  $\text{NH}_4\text{NO}_3$  and urea. The  $\text{NH}_4\text{-N}$  concentration from  $(\text{NH}_4)_2\text{SO}_4$  in the SE decreased from 152 ppm to 19 ppm during the season on unlimed soil and from 56 ppm to 8 ppm on limed soil. Symptoms of Mn toxicity in the leaves became apparent on unlimed plots 7 weeks after transplanting. As the rate of N increased in the range of 0, 50 and 100 kg  $\text{N-ha}^{-1}$  from urea the Mn contents were 372, 459 and 607 ppm respectively. The muskmelon fruit yield increase due to 100 kg  $\text{N-ha}^{-1}$  was 13279 kg  $\text{ha}^{-1}$ , 12161 kg  $\text{ha}^{-1}$  and 8502 kg  $\text{ha}^{-1}$  for ureas,  $\text{NH}_4\text{NO}_3$  and  $(\text{NH}_4)_2\text{SO}_4$ , respectively.

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### N-FORM EFFECTS ON NUTRITION OF SUMMER SQUASH

Willie O. Chance III\* and Harry A. Mills, Department of Horticulture, University of Georgia, Athens, GA 30602

Mature zucchini squash plants (*Cucurbita pepo* L.) were grown under four  $\text{NO}_3\text{:NH}_4$  ratios (1:0, 3:1, 1:1, and 1:3) to determine effects on macronutrient nutrition. Plants were grown in solution culture under greenhouse conditions. Treatments were applied at first bloom. Highest uptake of Ca and Mg occurred in the 1:0  $\text{NO}_3\text{:NH}_4$  treatment while higher K uptake was found in the 3:1  $\text{NO}_3\text{:NH}_4$  treatment. Total nitrogen uptake was greatest in the 1:1 and 3:1  $\text{NO}_3\text{:NH}_4$  treatments. A 3:1  $\text{NO}_3\text{:NH}_4$  ratio applied at first bloom gave best overall uptake of N, K, Ca, and Mg.

# WATERMELON RESPONSES TO MEHLICH-I-PREDICTED PHOSPHORUS FERTILIZER PROGRAMS

George Hochmuth\* and Ed Hanlon, Vegetable Crops and Soil Science Departments, respectively, University of Florida, Gainesville, FL 32611

Vegetable P fertilization recommendations in Florida are based on a soil test using the Mehlich-I (double-acid) extractant. For several Florida vegetables, including watermelon, there is a lack of crop correlation and extractant calibration data. Phosphorus fertilizer studies were conducted on sites with soils ranging in Mehlich-I P indices from 4 to 30 mg·kg<sup>-1</sup>. There was a quadratic yield response on soils testing 4 mg·kg<sup>-1</sup> P with yield maximizing at about 70 kg·ha<sup>-1</sup> fertilizer P. Watermelon did not respond to P additions on soils testing greater than 30 mg·kg<sup>-1</sup> of Mehlich-I P.

## 75 ORAL SESSION (Abstr. 473-480) CROSS-COMMODITY BIOTECHNOLOGY I

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### ASYMMETRIC PROTOPLASM FUSION IN TOMATO

P.F. McCabe, L.J. Dunbar, A. Guri and K.C. Sink\*, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824

Sexual hybrid plants of *Lycopersicon esculentum* × *L. pennellii* (E × P) have been transformed and the T-DNA inserts genetically mapped. Donor protoplasts of E × P were isolated from leaves, and subsequently irradiated with 0, 5, 10 and 20 krad of a <sup>60</sup>Co. They were then fused with suspension-derived protoplasts of *S. lycopersicoides* using the PEG-CA<sup>++</sup>-high pH technique. The protoplasts were cultured in medium 8E at 1.5 × 10<sup>6</sup> protoplast/ml. Selection of heterokaryon-derived macrocalli was facilitated by the inability of irradiated donor protoplasts to divide and by plating p-calli on regeneration medium containing kanamycin - an antibiotic for which the resistance gene NPTII is part of the T-DNA. Morphological characteristics of the resulting asymmetric somatic hybrid plants indicate that 10 and 20 krad irradiation eliminates a larger portion of the genome than does 5 krad. This has been confirmed with isozyme analysis and chromosome counts which generally show the 5 krad asymmetric somatic hybrid plants to differ little from symmetric hybrids although they contain some significant exceptions. Isozyme data reveals the 10 and 20 krad plants to have received much less of the donor genome. Exact quantification is continuing using isozyme markers, chromosome counts and cDNA probes.

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### STABLE GENETIC TRANSFORMATION OF CRANBERRY USING ELECTRIC DISCHARGE PARTICLE ACCELERATION

Rod Serres\*, Brent McCown, Dennis McCabe<sup>1</sup>, Elden Stang, Dave Russell<sup>1</sup>, and Brian Martinell<sup>1</sup>, Dept. of Horticulture, University of Wisconsin, Madison, WI 53706 and <sup>1</sup>Agracetus Corp., Middleton, WI 53562.

Electric discharge particle acceleration was used to introduce three foreign genes into the American cranberry (*Vaccinium macrocarpon* Ait.). These genes were NPTII (conferring resistance to the antibiotic, kanamycin), GUS (allowing for visual verification), and *B.t.* (conferring resistance to lepidopteran insects). Adventitious buds were induced on stem sections prior to bombardment with DNA-coated gold pellets. Bombarded stem sections were then transferred to a selection medium containing kanamycin. The surface of the medium was overlaid with a thin layer of kanamycin solution. Approximately 35 days after blasting, proliferating cell masses and elongating shoots were observed amidst the mass of kanamycin-inhibited tissue. Seven weeks after blasting, a histochemical assay verified GUS expression in these tissues, and polymerase chain reaction was used to confirm the presence of the introduced genes.

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### GENETIC ENGINEERING OF THE ZUCCHINI YELLOW MOSAIC VIRUS COAT PROTEIN GENE FOR EXPRESSION IN PLANTS. Guowei Fang\* and Rebecca Grumet. Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Zucchini yellow mosaic virus (ZYMV), a potyvirus, can cause major losses in cucurbit crops. With the goal of genetically engineering resistance to this disease we have engineered the

ZYMV coat protein gene into a plant expression vector. The complete coat protein coding sequence, or the conserved core portion of the capsid gene, was attached to the 5' untranslated region of tobacco etch virus (TEV) in the pTL37 vector (Carrington et al., 1987, Nucl. Acid Res. 15:10066). The capsid constructs were successfully expressed by in vitro transcription and translation systems as verified by SDS-PAGE and ZYMV coat protein antibody. The constructs were then subcloned using polymerase chain reaction and attached to the CaMV 35S transcriptional promoter on the CIBA-GEIGY pCIB710 plasmid. The constructs containing the CaMV 35S promoter, the 5' untranslated leader of TEV, and ZYMV coat protein sequences were then put between the *Agrobacterium tumefaciens* left and right borders in the pCIB10 vector and transferred to *A. tumefaciens* strain LBA4404 by triparental mating. These vectors are now being used to transform muskmelon and cucumber; resultant transgenic plants will be tested for ZYMV coat protein expression.

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### ENHANCING CELL RECEPTIVITY TO GENE TRANSFER BY ELECTRIC DISCHARGE PARTICLE ACCELERATION

Jim Sellmer\*, Dave Ellis<sup>1</sup>, Brent McCown<sup>1</sup>, Dennis McCabe<sup>2</sup>, Dave Russell<sup>1</sup>, and Brian Martinell<sup>2</sup>. Hort. Dept., Univ. of WI, Madison, WI 53706; <sup>1</sup>Agracetus, Middleton, WI 53562.

Successful recovery of plants transformed by direct gene transfer techniques relies on 3 factors: 1) a regenerable cell/tissue culture system, 2) a foreign DNA delivery system which can be fine tuned, and 3) a cell population receptive to the transfer and integration of foreign DNA into its genome. Cell receptivity to foreign DNA incorporation is being determined by bombarding poplar cells with gold particles coated with plasmid DNA containing a CaMV35s promoter β-glucuronidase chimeric gene construct. Histochemical GUS expression assays conducted after bombardment show that early log phase cells are most receptive with a transient transformation rate of 0.26% compared to 0.08–0.04% for mid log and stationary phase cells. Furthermore, cell receptivity in early log phase cells is decreased when cytokinin is removed from the culture medium for 3 growth cycles prior to bombardment. This response suggests that plant growth regulators may be used to enhance cell receptivity along with cell synchronizing agents.

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### EXPRESSION OF B-GLUCURONIDASE FROM AMELANCHIER LAEVIS Mark G. Bolyard\* and Mariam B. Stricklen, Dept. of Crop and Soil Sciences and Entomology, Pesticide Research Center, Michigan State University, East Lansing, MI 48824-1311.

Amelanchier laevis shoots were co-cultured with *Agrobacterium tumefaciens* carrying the binary vector pBI121, which encodes the B-glucuronidase (GUS) and neomycin phosphotransferase genes. Shoots were then rinsed briefly in liquid MS medium and plated onto culture medium containing carbenicillin. After approximately three months of culture, adventitious shoots were assayed for the presences of GUS by Southern blotting and histochemical assays. Southern analysis revealed a signal when genomic DNA from putatively transformed plants was hybridized with a probe from a segment of pBI121. Regenerated shoots also showed a deep blue color when incubated with X-gluc, although the expression was chimeric, that is, the activity appeared only in a percentage of the cells in each shoot. Callus tissue at the base of each shoot also showed high levels of GUS expression using a fluorogenic assay.

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### EXPRESSION OF PCH313 DURING FRUIT SOFTENING AND TISSUE WOUNDING

Ann M. Callahan, Peter H. Morgens, Reuben A. Cohen., Ken E. Nichols, Jr. and Ralph Scorza. USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV 25430

We are interested in identifying and isolating genes which affect the rate of softening in peach fruit. It may be possible through the engineering of these genes to delay or extend the softening. This could ultimately allow for the harvest and transport of more mature, higher quality fruit. The clone, pch313, was isolated from a ripe peach fruit cDNA library. RNA homologous to this clone is detected at a low abundance in fruit until softening when a >100fold increase in abundance of the RNA occurs. Pch313 RNA is also detected 30 min after wounding leaf or fruit tissue and peaks in accumulation within 2-8 hours. Wound ethylene was measured from the same tissue and its rate of evolution paralleled the accumulation of the RNA. The cDNA

was sequenced and found to have 78% sequence identity with pTom13, a tomato gene that is expressed during fruit ripening and wounding (Holdsworth et al., NAR 15:731-739, 1987). To determine the universality of pch313 related gene expression, RNA accumulation was measured in other fruits during softening, and in leaf tissue upon wounding.

#### 479 MOVEMENT OF GENETICALLY ENGINEERED XANTHOMONAS CAMPESTRIS PV. CAMPESTRIS IN THE ENVIRONMENT

Fenny Dane\*, Joe Shaw, and Joe W. Kloepper, Department of Horticulture, Botany and Microbiology, and Plant Pathology, respectively, Auburn University, Auburn, AL 36849

The bacterium *Xanthomonas campestris* pv. *campestris* (Xcc), causal agent of black rot disease in crucifers was tagged with the luciferase gene complex of the marine bacterium *Vibrio fischeri*. The growth of the bioluminescent strain in plants and the environment can be monitored by its light emissions. Susceptible cabbage plants were either mist, wound or debris inoculated in the field, soil was inoculated with debris or with suspension culture of genetically engineered Xcc. Plant, soil and air samples will be taken at biweekly intervals to monitor the spread of the bioluminescent bacterium within as well as outside the environmental release site. The transfer of exotic DNA to other bacteria in the environment will also be studied.

#### 480 GENE EXPRESSION PATTERNS OF PECAN ZYGOTIC AND SOMATIC EMBRYOS DURING MATURATION AND GERMINATION

Amnon Levi\*, Hazel Y. Wetzstein, Department of Horticulture, University of Georgia, Athens GA 30602 and Glen A. Galau, Department of Botany, University of Georgia, Athens, GA 30602

The coordinate expression of mRNA classes in pecan (*Carya illinoensis*) zygotic and somatic embryos has been studied. MRNA was isolated from zygotic embryos at early and late maturation stages (12 to 22 weeks post-pollination) and during germination. Additionally, mRNA was isolated from somatic embryos derived from a repetitive embryogenic system prior and after cold (6 weeks at 4°C) and desiccation treatments (5 days). These treatments have been determined to enhance somatic embryo conversion. The abundance of embryogenic mRNA classes was determined using various cloned cotton mRNA probes (Hughes and Galau, 1989). This study is a part of our efforts to elucidate the developmental and physiological differences between zygotic and somatic embryo systems in pecan.

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## 76 ORAL SESSION (Abstr. 481-488) CROSS-COMMODITY CROP PROTECTION

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#### 481 EFFECTS OF VACUUM DEVICES ON POPULATION OF LYGUS HESPERUS, VARIOUS BENEFICIAL INSECTS AND FRUIT QUALITY OF STRAWBERRIES

N.C. Welch, C. Pickel and D. Walsh, UC Cooperative Extension, 1432 Freedom Boulevard, Watsonville, CA 95076.

Two vacuum machines, a single row 950 cfm and a 3 row 3000 cfm of air movement were tested. Treatments: 1) weekly vacuum, 2) Biphenthrin and 3) Untreated.

Biphenthrin treatments significantly reduced the number per plant of lygus nymphs (0.2) and adults (0.7) vs. the vacuum treatments (3.1) and (0.31) and Untreated (4.6) and (1.2) in both tests. Damaged fruit was significantly less in the Biphenthrin treatments (4.4%) from the vacuum (15.5%) and Untreated (21.5%) plots.

There was significant reduction in lygus numbers and fruit damage in the vacuum plot, but fruit damage remained unacceptably high. Minute pirate bugs were the least affected by the vacuum treatments. Lace wings and spiders were somewhat more affected and big eyed bug populations were reduced by over 50%.

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#### MORTALITY AND DEVELOPMENT OF PEAR PSYLLA NYMPHS ON EAST EUROPEAN PEAR GERMPLASM

Richard L. Bell\* and L. Claire Stuart, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV 25430.

Four genotypes of pear (*Pyrus* spp.) of East European origin, a susceptible control, 'Bartlett' (*P. communis* L.), and a moderately resistant control, NY 10352 (*P. ussuriensis* Maxim. × *P. communis* B.C. hybrid), were artificially infested with pear psylla (*Cacopsylla pyricola* Foerster) nymphs in the laboratory. Ten neonate first instars were placed on each of the two youngest leaves of four small trees per genotype. On PI 506381 and PI 506382, wild seedlings of *P. nivalis* Jacq., all nymphs died within 5 days. Mortality and development of nymphs on PI 502173, a wild *P. communis* seedling, was similar to that observed on 'Bartlett', with 43% and 45% of the nymphs surviving to adulthood, respectively. On 'Karamanlika' (PI 502165) and NY 10352, 15% of the nymphs developed into adults. Increased mortality and delayed development of nymphs was associated with feeding inhibition. The mode of host plant resistance to pear psylla nymphs in these accessions of East European pear is, therefore, similar to that previously characterized for NY 10352, in which the resistance is derived from germplasm of East Asian origin.

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#### EFFECT OF MULCH COLOR ON TOMATO YIELDS AND ON INSECT VECTORS.

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

Field studies were conducted for three seasons, Fall 1988, and Spring and Fall of 1989 on the effect of six mulch colors: blue, orange, red, aluminum, white or black (fall or spring), and yellow on fruit yields and on insect vectors of 'Sunny' tomato. In Fall 1988, in a single harvest, fruit size was greater and total marketable yields were higher with blue than with aluminum and yellow mulches. In Spring 1989 early yields of large (> 70 mm) and marketable fruit were higher with aluminum and red than with yellow and blue mulches. In Fall 1989 early yield of large fruit was higher with white than with yellow mulch. Early marketable yields were highest with white and aluminum mulches. Total yields of large fruits were highest with orange and blue mulches but marketable yields were similar with all six mulch colors. The fewest number of aphids, thrips and whiteflies were trapped on aluminum mulch. Blue mulch attracted the largest number of aphids and thrips. Red mulch attracted whiteflies. The three insects are important vectors of several virus diseases.

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#### GROWTH, YIELD, QUALITY, AND INSECT CONTROL OF CABBAGE AS INFLUENCED BY FLOATING ROW COVERS, MULCH, AND COLOR

Helen C. Harrison, Department of Horticulture, University of Wisconsin, Madison, WI 53706

This 1988-1990 field study was designed to: evaluate the effectiveness of wide width floating row covers (covers remained over the crops the entire growing season), polyethylene mulch, and mulch color--red, green, and black--on the growth, yield, quality, insect, and weed control for red ('Red Danish') and green ('Resistant Danish') cabbage cultivars. Insect control treatments included Agrotent floating row covers, periodic sprays with dipel, and no insect control. Subplots for weed control were: PPI Treflan and black, green, and red polyethylene mulch. Sub-subplots were red and green cabbage cultivars. Annual rye grass was utilized as a living mulch between the polyethylene strips.

One of the purposes of this research was to perfect a pesticide-free system for small-scale vegetable production. Preliminary results indicate few color effects but do show that cabbage can be grown under row covers the entire growing season. However, the covers can become brittle after 2 months of exposure to sunlight. Significant cultivar differences for insect and disease resistance were observed.

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#### SOIL TYPE AND POTTING MEDIUM INFLUENCE ON RUST PUSTULE GRADE (SIZE) ON DRY BEAN LEAVES (*Phaseolus vulgaris* L.)

Haytham Z. Zaiter\*, Dermot P. Coyne, Ralph B. Clark, and James R. Steadman, American University of Beirut, Lebanon and University of Nebraska, Lincoln, NE 68583

Nine bean cultivars/lines were grown in a Tripp sandy-clay loam (high pH), a Sharpsburg silty clay loam (neutral pH), and a potting mix (equal volume of sand, soil [Sharpsburg silty clay loam], vermiculite and moss peat) (low pH) in greenhouse

(one experiment), growth chamber (two experiments), and field (two experiments) in Lincoln, NE, in order to evaluate the leaf reaction of the plants to a Nebraska rust (*Uromyces appendiculatus* var. *appendiculatus*) isolate US85-NP-10-1. A factorial arrangement of soil media and cultivars/lines in a randomized complete block design was used in the greenhouse and growth chamber experiments, while a split-plot design (soil media as main plots and cultivars/lines as sub-plots) was used in the field experiments. Significant differences were observed for rust pustule size of cultivars/lines grown on the three different soil media. Plants grown on potting mix medium showed significant increases in rust pustule size compared with Tripp (high pH) or Sharpsburg silty clay loam soils (neutral pH). A significant interaction occurred between soil media and cultivars/lines for the rust reaction. A positive correlation ( $R = +0.5$ ) was observed between the increased concentration of C1 and Mn, and a negative correlation for lower K ( $R = -0.44$ ) and soil pH in the potting mix and larger rust pustule size of leaves. These results have implications for plant breeders and pathologists involved in evaluating bean progenies and lines for rust resistance.

#### 486 POPULATION DYNAMICS OF APHIDS ON BROCCOLI IN THE MEXICAN BAJIO VALLEY.

Alfonso Hernández-Barajas\*, José Luis Vera-Medina and Dr. Benito Alvarado-Rodriguez., Campbell's de México, S.A. de C.V. Apdo. Postal #285, Celava, Gto. México 38000.

During a two-year-period, a study was made in the field in order to know the occurrence of aphids in the broccoli crop. It was possible to know that the total aphid population is higher in winter plantings where more than 240 aphids/plant were found. Spring and fall plantings, in comparison, less than 20 aphids/plant were encountered. The species more common were the cabbage aphid (*Brevicoryne brassicae* L.), the most prevalent species in the crop, getting more than 80% of the population, and the green peach aphid (*Myzus persicae* Sulzer) with a little bit more than 17% of the total. The natural parasitism in all plantings was around 17%. By species, parasitism in *B. brassicae* was higher in springs (70% of the total) and fall plantings where the parasitic wasp *Diaretiella rapae* (MacIntosh) was probably more active. The same pattern was obtained for *M. persicae*, in which the parasitism was again higher in spring and fall plantings (20% of the total) and very low during the winter. Regarding leaf preference, a very defined pattern was found in the *M. persicae* than for *B. brassicae*.

#### 487 INTERFERENCE OF BLACK AND EASTERN BLACK NIGHTSHADE WITH TRANSPLANTED TOMATOES. Milton E. McGiffen, Jr.\*, John B. Maslunas, and Morris G. Huck, Departments of Horticulture and Agronomy, University of Illinois, Urbana, IL 61820.

Eastern black nightshade (*Solanum ptycanthum*) and black (*Solanum nigrum*) nightshade are difficult to control in tomato, interfering with harvest and decreasing fruit quality and yield. In irrigated tomatoes, soil water depletion was greater as nightshade density increased. However, tomato yield loss due to black nightshade was greatest at the lower weed densities. As density increases, photosynthetic activity (photosynthetic rates, stomatal conductance, intercellular  $CO_2$  concentration, and stomatal resistance) of black nightshade is more affected than eastern black nightshade. Photosynthetic activity of tomato is the least affected. In greenhouse experiments where water was denied for approximately a week prior to measurement, tomatoes were more sensitive to water stress than were nightshades. Nightshades were more adapted to drought stress than were tomatoes.

#### 488 ALLELOPATHIC CONTROL OF AMARANTHUS SPP. BY ALLIUM SPP. Charles Macharia\* and Ellen B. Peffley, Department of Agronomy, Horticulture, and Entomology, Texas Tech University, Lubbock, TX 79409.

The genus *Amaranthus* contains many species which are common weeds found on the Texas high plains. In a field experiment plant height and numbers of plants of *Amaranthus* varied when grown with different *Allium* genotypes: *Allium fistulosum* var. 'Heshiko' and an interspecific F<sub>1</sub> hybrid 81215 (*Heshiko* × *A. cepa* cv. 'New Mexico Yellow Grano'). The genotypes that showed no allelopathic effect were *A. cepa* cv. 'New Mexico Yellow Grano', *A. fistulosum* var. 'Ishikura', and their F<sub>1</sub> hybrid 8273. On the basis of these observations experiments have been done to quantify the degree of suppression. A randomized complete block design was used under greenhouse conditions in order to measure growth characters of *Amaranthus*.

## 77 ORAL SESSION (Abstr. 489-496) CROSS-COMMODITY POSTHARVEST TECHNOLOGY

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#### CORRELATION AMONG CHANGES IN THE NUCLEAR MAGNETIC RESONANCE IMAGE OF RIPENING TOMATO FRUIT AND OTHER RIPENING PARAMETERS

M.E. Saltveit, Department of Vegetable Crops, Mann Laboratory, University of California, Davis, CA 95616

Tomato fruit undergo an orderly series of physiological and morphological changes as they progress from mature-green (MG) to red-ripe. Fruit are commercially harvested at the MG stage, a stage which often encompasses fruit of varying degrees of maturity. The ability to predict the time required for MG fruit to ripen would reduce variability in experiments and could be commercially used to pack fruit that would ripen uniformly. Nuclear magnetic resonance (NMR) imaging can nondestructively measure internal changes associated with plant growth and development. In this study, NMR images were taken of freshly harvested tomato fruit (*Lycopersicon esculentum* cv. Castlemart) at different stages of maturity and ripeness. Measurements were also made of the stage of ripeness, rate of respiration and ethylene production, lycopene and chlorophyll content, density of the pericarp wall, and condition of locular tissue. NMR images showed substantial changes in the pericarp wall and locular tissue during maturation and ripening of tomato fruit. However, it was difficult to objectively evaluate these visual changes with other ripening parameters. For example, increased lightness and graininess of the pericarp wall image was associated with a decrease in wall density; while lightening of the locular image was associated with tissue liquefaction. Use of NMR imaging in studies of tomato fruit ripening will be discussed.

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#### NEAR-INFRARED SPECTROPHOTOMETRY FOR MEASUREMENT OF SOLUBLE SOLIDS IN INTACT HONEYDEW MELONS

Gerald G. Dull\*, Richard G. Leffler and Gerald S. Birth, United States Department of Agriculture - Agricultural Research Service, Richard B. Russell Agricultural Research Center, P. O. Box 5677, Athens, GA 30613

A near-infrared spectrophotometric method for estimating the soluble solids in honeydew melons is presented. The method is based on a body transmittance geometry in which the angle between the source incident beam and the detector is approximately 45°. The regression analysis of the spectral and chemical data utilizes a ratio of two second derivatives and resulted in a correlation coefficient of 0.85 and a standard error of calibration of 1.5. The numerator wavelength occurs in a carbohydrate absorption band, thus the method can be interpreted as a measurement of carbohydrates.

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#### USE OF TIME TEMPERATURE MONITORS FOR PREDICTING SHELF LIFE OF FRESH FRUITS AND VEGETABLES

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Shelf life of perishable commodities is a function of time by temperature effects on the composite kinetic reactions within each commodity. Empirical tests to approximate shelf life have limited value, particularly in long-distance shipment when less than ideal storage conditions occur, such as for the export market. Time temperature monitors (TTMs) have been developed for monitoring storage temperatures and predicting remaining shelf life. Kinetics curves for ripening of pears, yellow color development in broccoli and browning of mushrooms were compared to kinetics properties of available TTMs at 5, 10, and 20°C. Each commodity deteriorated or ripened at rates corresponding to a different TTM. At 20°C, broccoli kinetics were similar to TTM MC 60 or 67, pears to MC 74, and mushrooms MC 66. Customized TTMs and application of this technology will be discussed.

# COMMERCIAL ROOM COOLING, HYDROCOOLING, AND FORCED-AIR COOLING OF SNAP BEANS IN WOODEN CRATES AND CORRUGATED CARTONS: EFFECTS ON QUALITY.

Jeffrey K. Brecht\*, Steven A. Sargent, Vegetable Crops Department, IFAS, University of Florida, Gainesville, FL 32611, and L. A. Risse, U.S. Department of Agriculture, ARS, 2120 Camden Road, Orlando, FL 32803

Snap beans were room cooled (RC) or forced-air cooled (FA) in a 4.5°C commercial cold storage room, or hydrocooled (HC) in a commercial flume-type unit with 4°C water containing 175 ppm NaOCl. The beans were packed in wirebound wooden crates (WC) or waxed corrugated fiberboard cartons (FC) before (RC, FA) or after (HC) precooking and stored one week at 10°C before evaluation. Ascorbic acid, chlorophyll and fiber contents did not differ among treatments, while moisture content and per cent unshrivelled beans were lowest in FA and highest in HC, and lower in WC than in FC containers. HC reduced development of mechanical damage symptoms (browning) and decay compared to RC and FA. The former effect was attributable to the presence of NaOCl rather than leaching or increased cooling rate in HC. HC beans packed in FC had the highest per cent sound beans and lowest per cent beans showing mechanical damage symptoms of all the treatment combinations tested.

# MODIFIED ATMOSPHERE PACKAGING (MAP) OF BELL PEPPER FRUIT

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The objective of this work was to evaluate the effect of individual seal-packaging using low density polyethylene films and waxing treatments on the storage ability and quality of Bell pepper fruit. The fruits were packaged in two kinds of films, waxed and unwaxed and kept at 10°C and 75% RH for 46 days. Characteristics of the films (Thickness and permeability for O<sub>2</sub> and water vapor) were determined. Atmosphere changes (O<sub>2</sub> and CO<sub>2</sub>) inside the packages were followed each 5 days. Fruits were evaluated every 10 days, for changes in color, % chlorophyll, texture, soluble solids, acidity, PH, weight loss, % decay and sensory characteristics. The activity of ADH enzyme was used as an indicator of anaerobiosis. MAP + waxing significantly delayed fruit ripening, reduced the losses of chlorophyll, weight, firmness and % of decay respect to the unwaxed and unwrapped fruits (control) and did not result in any abnormal flavors after 20, 30 and 40 days at 10°C. These quality factors demonstrate that MAP + waxing can be used to prolong the shelf life for up to 20 days without affecting the eating-quality of the fruit.

# THE EFFECT OF CHITOSAN COATING ON THE SHELF-LIFE OF GREEN PEPPERS AND CUCUMBERS.

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The effect of chitosan coating on green peppers and cucumbers stored at 13°C and 85% R.H. on weight loss, quality and respiration was assessed. Chitosan coating markedly reduced the weight loss of both green peppers and cucumbers, with greater effect at higher concentration. In addition, color loss, wilting, decay and respiration was significantly lower in coated fruits than in the control.

The results of this study indicate that the mechanism by which chitosan coating delay senescence in green peppers and cucumbers is more likely due to its ability to alleviate water stress than to modify the internal microatmosphere.

# NITROGUANIDINES, A NEW FAMILY OF PGRs, INHIBIT SENESCENCE OF LEAVES AND VEGETABLES

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Nitroguanidines are a new family of synthetic plant growth regulators (Speltz, Walworth, and Pavlista 1986. US Patent #4, 594, 092) These compounds have cytokinin-like activity such as delaying senescence. Three compounds are AC239, 604, AC243, 419 and AC132, 654 The first two are phenyl and the latter is a benzyl nitroguanidine. Examples of anti-senescence activity

of these compounds are: 1. sunflower leaves, 2. tobacco leaves, 3. leafy lettuce, 4. kale, 5. collards, and 6. Swiss chard. The senescence of cut ornamental flowers is also inhibited. Examples are gladiolus and daffodils. Along with delaying senescence, AC239, 604, for example, increased leaf size, thereby, increasing yield of leaf crops such as tobacco (Pavlista and Templeton. 1987. PGRSA Proc.) and lettuce.

# POTATO QUALITY IMPROVEMENT FOR PROCESSING

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The development of dark color is often a major problem in the processing of potatoes. This is due, in large part, to the reaction of reducing sugars with amino acids upon the application of heat during processing. Several chemicals have been shown which, when applied to foliage in the field, will decrease reducing sugars and dark color in processed potatoes.

## 78 ORAL SESSION (Abstr. 497-503) CROSS-COMMODITY SEED PHYSIOLOGY I

# THE INFLUENCE OF ALTERNATING TEMPERATURES ON GERMINATION AND FATTY ACID CONTENT OF APPLE SEEDS

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Seeds of 'Golden Delicious' apple (*Malus domestica* Borkh.) were exposed to constant and alternating chilling temperatures. Germination was reduced in seeds treated with 4/11, 4/13, and 4/15 C for 16/8 h, respectively, compared to those treated at a constant temperature (4 C). The 4 C reached 100 % germination after 1600 h, the 4/11 C after 1864 h, and the 4/13 C after 1973 h at 4 c. The 4/15 C never reached complete germination even after 2200 at 4 C. The predominant fatty acids during stratification at constant and alternating temperatures were palmitic, oleic, and linoleic acids. Stearic acid was found at a lower level. Arachidic and behenic acids were only found in constant temperature treatment. There were no significant changes in fatty acid content during stratification at constant and alternating temperatures except that the 4/11 C treatment increased levels of palmitic, oleic, and linoleic acids.

# CHANGES IN GLUTATHIONE AND CATALASE ACTIVITY ASSOCIATED WITH BREAKING OF DORMANCY IN CHERRY SEEDS.

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Many seeds of woody plants require low temperature or other treatments to overcome dormancy. Changes in catalase activity and glutathione has been proposed to be associated with the breaking of dormancy. We examined the level of glutathione and catalase activity of cherry seeds (*Prunus mahaleb* cv. *Lambert*) exposed to several dormancy breaking agents. Seeds imbibed in water for 24 hrs. were either stratified at 4°C or at 25°C for up to 12 weeks, or exposed to other dormancy breaking agents. Germination test, glutathione and catalase activity were determined weekly and/or after treatment. Analysis of levels and state of glutathione were performed by high pressure liquid chromatography (HPLC), and catalase activity was assayed spectrophotometrically. Total glutathione in dry and imbibed seeds were similar, but, ratio between the reduced and oxidized form were different. Low temperature stratification for 12 weeks increased the reduced form of glutathione six-fold, while percent germination increased up to 94%.



# GROWING DEGREE DAYS AS A METHOD FOR DETERMINING CARROT SEED HARVEST

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Carrot (*Daucus carota* L.) seed quality is affected by the environment in which it matures. Substantial differences in germination from year to year and from field to field have been recognized for many years for umbelliferae seed. Part of the explanation for low germination appears to be the harvest of immature seed. Data was collected for two years, from fields of the cultivars Chantenay and Nantes. Approximately 550 growing degree days were accumulated from anthesis until maturity for seed from the primary umbel. Growing degree days were calculated using a 10°C base temperature and without truncating for temperatures in excess of 35°C. Secondary, tertiary, and quaternary umbel seed maturity sequentially followed primary umbel seed. Secondary and tertiary umbels produced approximately 80 percent of the total seed yield while the primary and quaternary umbels produced approximately 20 percent. Seed maturity was determined by measuring the germination rate. Immature seed germinate at a slower rate than mature seed. The implications of these results for obtaining high quality carrot seed will be discussed.

500

# IMBIBITION, ELECTROLYTE LEAKAGE, AND GERMINATION OF SWEET CORN HYBRIDS CARRYING sh2 MUTANT ENDOSPERM

Carlos A. Parera\* and Daniel J. Cantliffe, Vegetable Crops Department, University of Florida, Gainesville, FL 32611

Seeds of two shrunken-2 (sh2) sweet corn (*Zea mays* L.) cultivars, Crisp N' Sweet 711 and How Sweet It Is were used to analyze seed quality factor differences between the cultivars. Negative correlations occurred among germination percentage and imbibition, electric conductivity, potassium concentration and total soluble sugars of the seed leachate. Imbibition and total soluble sugar in the leachate significantly increased as imbibition temperature increased from 5°C to 25°C in both cultivars. A significant increase in conductivity of the leachate also occurred in 'Crisp N' Sweet 711' when temperature increased. Cracks in the seed coat were more frequent in 'How Sweet It Is' than 'Crisp N' Sweet 711'. The higher concentrations of soluble sugars in the seed, greater imbibition rate, leakage conductivity, potassium and sugar concentration in the leachate may have been directly related to the poorer seed quality of 'How Sweet It Is'. The alteration in cell membrane structure caused by a rapid water uptake in 'How Sweet It Is' may have led to the high concentration of electrolytes in the seed leachate. This, in turn, might provide a greater nutritive substrate for fungi development.

501

# EFFECTS OF STORAGE ON THE GERMINATION AND VIGOR OF MUSKMELON SEEDS FROM DIFFERENT STAGES OF DEVELOPMENT

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It is unclear from previous reports whether muskmelon seeds require an afterripening period to attain maximum germinability and vigor. In the current study, seeds ranging in age from 30 to 60 days after anthesis were stored at water contents ranging from 3 to 15% and at either 6 or 30°C to determine whether seed vigor increased during storage. Changes in vigor were assessed by conducting monthly germination tests on blotter papers saturated with water or polyethylene glycol solutions of known water potential. The germination percentages of immature seeds (30 and 35 DAA) were dramatically improved by 3 months of storage at low water content and temperature, while the mean time to germination and the variability of germination were reduced for all stages of development. Germination percentages in water decline after storage at high water content and temperature with immature seeds showing a greater rate of decline than mature seeds but at reduced water potentials, the same adverse storage conditions increased the germination percentages and rates of mature seeds. However prolonged storage under adverse conditions, resulted in a gradual decline in water stress tolerance. Afterripening occurred over a wide range of storage conditions and significantly improved seed vigor, particularly in immature seeds. Furthermore, the increases in vigor achieved from afterripening treatments were remarkably similar to the increases in vigor attained through priming. Priming may substitute for the afterripening requirement of muskmelon seeds.

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# TOWARDS A NON-DESTRUCTIVE SEED TEST

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An index "internal slope" derived from the cumulative frequency distribution of individual seed leachate conductivities is related to seed quality; the larger the

index value the less variation among individual seeds in a sample (100 seeds) and the higher the seed quality. We have recently developed data acquisition/instrument control/data smoothing/data analysis software which accesses frequency and cumulative frequency distributions of individual seed conductivities and the derived index on an almost continuous basis from the start of the first soaking.

At present, lack of convergence with regard to curve fitting may occur necessitating multiple sampling times. A "window in time" approach is described whereby index estimates during a two-hour interval within the index stability phase are averaged. Evidence of the method's ability to assess seed vigor will be presented.

503

# THE EFFICACY OF A SOAK TEST FOR PREDICTING THE PERFORMANCE OF IMPATIENS SEEDS IN PLUG PRODUCTION SYSTEMS.

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Fifteen lots of impatiens representing five cultivars were used to evaluate the potential of a soak test for predicting the performance of impatiens seeds in plug-production systems. This test would be valuable in breeding programs because it is non-destructive, seed-specific, inexpensive, fast, and does not require large numbers of seed. The soak test submerged individual seeds in one ml distilled water during germination. The results of this test were compared to standard blotter germination and to plug tray performance in the Iowa State University greenhouse and at two commercial greenhouses. Different responses to the soak test were found among lots and cultivars but the differences could not be correlated to the plug tray performance of the seeds. The responses to the soak test do not appear to be genetically related for these cultivars.

## 85 ORAL SESSION (Abstr. 504-511) FRUIT CROPS: CULTURE AND MANAGEMENT II

504

# INSTANTANEOUS AND INTEGRATED LIGHT MEASUREMENTS WITHIN AN APPLE CANOPY

Richard J. Campbell\* and Richard P. Marini, Department of Horticulture, Virginia Tech, Blacksburg, VA 24061

Integrative measurements of photosynthetically active radiation (PAR) were made at 30 'Delicious' canopy positions throughout the season to characterize the canopy light environment. Instantaneous measurements (IM) of PAR were made at the same positions with a quantum sensor on clear and overcast days and correlated with integrated seasonal PAR. Hourly (1100, 1200, 1300, and 1400 hrs) IM made on clear days were influenced by sunflecks and had variable relationships with integrated values ( $R^2 = 0.52-0.90$ ). This was improved by using the average of the four IM measured during the day ( $R^2 = 0.92$ ). Hourly IM on overcast days were consistent and highly correlated to integrated values ( $R^2 = 0.97$ ). IM from overcast days were reliable predictors of seasonal PAR and could be used to characterize the canopy light environment.

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# FRUIT QUALITY DEVELOPMENT OF 'GRANNY SMITH' APPLES IN RESPONSE TO TREE CANOPY LIGHT MICROCLIMATE.

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A preliminary study suggested light distribution (400-700nm) did not change from terminal bud set (July) to harvest (9/9/88). Therefore, limbs of 5-year-old trees

were shaded the last 90 days of the season in 1988 and 7-year-old trees were shaded the last 60 days in 1989 with 30, 63, 95% or no shade cloth. Medium (63%) and heavy (95%) shade decreased fruit weight both years. Fruit soluble solids (SSC) decreased with increasing shade in 1988 but not in 1989 until after 60 days of storage. Fruit peel chlorophyll (chl) declined with time for all treatments. Apples from full sun and heavy shade treatments had the lowest chl and visually appeared the lightest. Evidence from both years suggested there was an optimal light level between 37-70% full sun for maximum fruit color and chl. Link of 7-year-old trees were shaded at intervals, light all season, mid-season and late season. Fruit weight and firmness were not affected by time of shading. SSC was liner for mid-season shaded fruit. Chl was highest for late season shaded fruit but differences evaporated by 90 days of storage.

506

#### ORCHARD DESIGN OF SOUR CHERRY IS YIELD RELATED TO LIGHT INTERCEPTION?

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The objective of this experiment was to design orchard systems and tree shapes that optimize production based upon light interception. 'Montmorency' on 'Mahaleb' rootstock was established at the Clarksville Horticultural Research Station in 1982. The following factors were investigated: a) tree shape; free form,  $\Delta$  triangle and  $\bullet$  rectangle, b) tree height to clear alleyway width ratios; 1.5, 2.0 and 2.5, and c) tree density 3.0 $\times$ 4.5 m, 3.0 $\times$ 6.0 m. Tree shape was established beginning in the 3rd leaf by summer hedging on an annual basis at the end of stage II of fruit growth. Beginning with the 4th leaf, light interception in each system was estimated by measuring the light interception below the canopy at hourly intervals after full canopy development. In 1989, yields ranged from 14,000 to 22,000 Kg ha<sup>-1</sup>. Ripening was delayed for rectangle shaped trees, with a height to clear alleyway, width ratio of 1.5, spaced 3.0 $\times$ 4.5 m, likely because hedging reduced leaf to fruit ratios. Within a tree form, yield was linearly related to % light interception, however rectangular trees were more productive than triangle shaped trees. The relevance of this study to orchard design will be discussed.

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#### RESPONSE OF SOUR CHERRIES TO FOLIAR BORON SPRAYS

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

Field trials were conducted in 1988 and 1989 in several Michigan locations to determine if fruit set and yield of sour cherry (*Prunus cerasus* L. cv 'Montmorency') can be increased by boron (B) applications. Orchards varied in age (6-12 years) and initial leaf B concentrations (18-32 ppm dry weight). Treatments consisted of an unsprayed control and B sprays (500 ppm B) applied to the leaves in Sept. Fall B sprays increased B concentrations in flowers the following spring by 50-100%. The percentage of flowers which set fruit was either unaffected by sprays or increased by as much as 100%. Fruit yields were unaffected by B sprays in some trials, and increased by as much as 100% in others. No visual symptoms of B deficiency were observed. Results of 1990 trials will also be presented.

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#### PRELIMINARY PERFORMANCE OF NEW GERMAN AND BELGIAN CHERRY ROOTSTOCKS IN MICHIGAN AND NEW YORK

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In 1987, the NC 140 Regional Rootstock Testing Committee established sweet and sour cherry rootstock trials in 16 locations in North America. This paper will present preliminary results on the performance of Hedelfingen (sweet) and Montmorency (sour) cherry cultivars at the New York and Michigan sites. The rootstock under test include 3 clones from Gembloux, Belgium, Colt, 4 MxM hybrids, and 9 to 13 interspecific hybrid clones from Giessen, West Germany. Clonal rootstock also under test for Montmorency include St. Lucie 64, 275 and, in New York, Holly Jolivet. Rootstock treatments differ slightly among sites and are replicated 7-8 times in a randomized

complete block design. The Giessen rootstock 148/1 and 195/1 have, to date, demonstrated excellent influence on sweet cherry precocity. Sweet and sour cherry on Colt and the MxM hybrids have been most vigorous at both sites. Montmorency is most precocious on Mahaleb seedling followed by Giessen 148/1 at both locations. Data for 1990 on rootstock performance will be included in the oral presentation.

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#### STUDIES ON PAPAYA PRODUCTION IN MIDDLE GEORGIA

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Three exotic lines (Dwarf, L-45, and L-50) of precocious papaya (*Carica papaya* L.) from India, were grown in nursery rows at the Fort Valley State College Agricultural Research Farm during 1986-1990. Performance of these lines was evaluated for their adaptation and production feasibility under the growing conditions of Middle Georgia. Two lines (L-50 and Dwarf papaya) showed a less satisfactory overall performance than did L-45, which had the highest female to male ratio (7:3) and abundantly produced tree-ripened fruits under cold protection frames during 1989 and 1990. Tree growth and survival for L-45 were greater than those for L-50 and Dwarf papaya lines. Two-month-old greenhouse-grown seedlings when established in the field in April, flowered in 60 to 65 days following transplanting. Under Georgia conditions, fruits ripened on trees in approximately 150 days after fruit set. During 1989-90, the fruit size on L-45 trees varied from 574 g to 2,286 g (mean 1,530 g) with an average of 22.5 fruits per tree. Four years data suggest that papaya can be a successful annual crop if shelter is provided during late fall to protect ripening fruits and trees from frost/cold.

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#### NORTHERN PECAN CULTURE IN NEBRASKA

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The Northern Pecan Research Program was established in 1979 and designed to determine the potential of growing the northern pecan as both an ornamental shade tree and as a possible crop in Nebraska. In 1983, 2 year old seedlings planted in 1981 were grafted to 54 superior pecan clones/cultivars (total of 324 trees) in a two-acre orchard in Lincoln, NE. Most of these clones were selected from native trees growing in and along the Mississippi River Valley in Northeast Iowa/Northwest Illinois, and the Missouri River Valley in Northwest Missouri/Northeast Kansas. These pecans were specifically selected for having the potential to survive winter temps to -35° F and produce crops in a 130-180 day growing season. There is now a need to research the production of pecans in a commercial orchard situation. The past 9 years of research has demonstrated that pecans will survive and produce an edible crop with excellent quality and food value.

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FACTORS INFLUENCING PREHARVEST FRUIT SPLITTING IN ELLENDALE (*C. reticulata*). Etienne Rabe\*, Piet van Rensburg, Hennie van der Walt and John Bower, Outspan Citrus Centre, P O Box 28, Nelspruit 1200, Republic of South Africa.

Preharvest fruit splitting (PFS) is a serious problem in Ellendales, especially in hot, humid climactical areas. In control unsprayed treatments PFS can vary from 14 to 30% of the final yield. Any treatment during the fullbloom (FE) period aimed at increasing fruit set (gibberellic acid (GA) sprays, girdling), increases PFS levels, ranging from 40 to 60% of the final yield. This relates to a significant shift (delay) in the normal fruit drop pattern as compared to untreated trees.

We have evaluated various approaches aimed at reducing PFS in Ellendales: potassium treatments, from 10 weeks pre-blossom to six weeks after full-bloom, however, increased PFS levels, possibly due to increasing the initial fruit set levels; flower thinning, both chemical and mechanical, marginally reduced PFS, without adversely affecting yield; post-November drop GA application, 2,4-D and girdling treatments, aimed at stimulation of rind growth (not quantified) increased yields significantly ( $P < 0.05$ ) without concurrent increases in PFS.

Cross pollinated trees, and resultant high seed content in the fruit, yielded fruit with thicker rinds, with little or no PFS. GA application at FE reduced fruit seed content and peel thickness and increased PFS.

Any treatment causing high initial fruit set increases PFS. Flower: flower and fruit: fruit competition should be reduced early during the fruit growth phase, without adversely affecting final yields.

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DETECTING PEACH WATER STRESS THROUGH CHANGES  
IN FOLIAGE TEMPERATURE

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The response of foliage-air temperature differential ( $T_f-T_a$ ) to  
vapor-pressure deficit (VPD) as a means of detecting incipient water  
stress was investigated in the Illinois planting of the NC-140 Uniform  
Peach Rootstock Trial. Stomatal conductance, foliage temperature,  
leaf water potential, air temperature and VPD were followed diurnally  
on three dates in 1989 for mature 'Redhaven' on six different  
rootstock. On two of three sampling dates where predawn leaf  
water potential was greater than -0.5 MPa there was no indication of  
midday stomatal closure and all rootstock exhibited an inverse  
relationship between  $T_f-T_a$  and VPD. On the date with the most  
negative predawn leaf water potential,  $T_f-T_a$  of two plum rootstock  
(GF-677 and GF-655-2) was observed to be significantly greater at  
VPD levels above 2 kPa than the remaining rootstock. All rootstock  
on this date exhibited greater  $T_f-T_a$  than at similar VPD  
levels on the other two dates. These data suggest that transpirational  
cooling plays a large enough role in foliage temperature  
regulation of 'Redhaven' peach such that incipient water stress and  
rootstock effects on water relations can be detected through  
increases in foliage temperature.

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CLASSIFICATION OF STRESS-INDUCED SPATIAL  
VARIABILITY IN NEAR-INFRARED CANOPY REFLECTANCE.

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A digital video camera (Panasonic Industrial Co., Secaucus, NJ)  
with a 1.7 cm charged coupled device detector (574 (h)  $\times$  499 (v) pixel  
elements) was modified with a custom made FRF-700 band pass filter  
to visualize canopy reflectance in the near-infrared (NIR) from 700 to  
1100 nm. Images of canopy reflectance under a range of  
environmental stresses were obtained from peach and apple trees  
under greenhouse and field conditions. Individual video frames were  
digitized with Image Capture and Analysis System (Agri Imaging  
Systems, Inc., Fayetteville, AR). Image contrast was increased with  
digital equalization and filtering before classification into one of five  
stress levels. There was a high correlation ( $r^2 > 0.8$ ) between leaf  
stress and canopy reflectance in both apple and peach at distances <  
5 meters. Spatial variability in stress-induced NIR reflectance could  
be detected and classified at vertical distances from 150 to 500 M.  
Analysis of vertical imagery revealed sections of the orchard which  
were most susceptible to environmental stress.

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SCREENING ALMOND CULTIVARS FOR OZONE SUSCEPTIBILITY

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Uniform nursery stock of five almond cultivars (*Prunus  
dulcis* Mill., cv Nonpareil, Mission, Carmel, Butte, and Sonora)  
propagated on peach (*P. domestica* L. Batsch.) rootstock were  
planted in open-top fumigation chambers on 19 April 1989 at the  
University of California's Kearney Ag Center located in the San  
Joaquin Valley of California. The trees were exposed to three  
atmospheric ozone partial pressures (charcoal filtered air,  
ambient air, or ambient air+ozone) from 1 June to 2 November  
1989. The mean 12-h (0800-2000 h) ozone partial pressure  
measured in the open-top chambers during the experimental  
period averaged 0.038, 0.060, and 0.112  $\mu\text{Pa Pa}$  ozone in the  
charcoal filtered, ambient, and ambient+ ozone treatments,  
respectively. Leaf net  $\text{CO}_2$  assimilation and cross-sectional  
area growth of Nonpareil trees were reduced by increasing  
atmospheric ozone partial pressures, but Mission trees were

unaffected. Foliage of Nonpareil almond abscised prematurely  
in the ambient and ambient+ozone treatments. The susceptibility  
of the Butte, Carmel, and Sonora almond cultivars to ozone was  
intermediate between the Nonpareil and Mission cultivars.

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SALINITY AFFECTS GROWTH AND NET GAS EXCHANGE OF CARAMBOLA  
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Salinity effects on growth and net gas exchange of  
carambola (*Averrhoa carambola* L.) examined in were  
greenhouse culture with ten-month-old seedlings in perlite:  
peat: sand: pine bark chip medium in 5.1 liter (21 cm top  
dia.) containers. Treatments of 0.05, 5.1, 9.5, or 13.9  
 $\text{dS}\cdot\text{m}^{-1}$  were obtained by dissolving ca. 0, 2.5, 5.0, or 7.5 g  
of dehydrated sea salt per liter of rain water and delivered  
from elevated tanks by gravity to dribble ring emitters in  
containers via polyethylene and q micro tubing. All plants  
except control plants received 5.1  $\text{dS}\cdot\text{m}^{-1}$  beginning 25 Nov.,  
and concentration was gradually increased for the two  
highest salinity levels until reaching 9.5  $\text{dS}\cdot\text{m}^{-1}$  on 3 Dec.  
and 13.9  $\text{dS}\cdot\text{m}^{-1}$  on 7 Dec. Plants were watered twice weekly  
until 1 March 1990. Stomatal conductance was determined  
(LI-COR 1600 steady-state diffusion porometer) on 7 day  
intervals beginning 24 Nov. Growth was determined as leaf  
area (LI-COR 3000 area meter), plant dry weight, and trunk  
diameter. Stomatal conductance declined in all salinity  
levels to 50% or less of controls by day 12, with a gradual  
further decline thereafter. Leaf area, plant dry weight,  
and trunk diameter declined linearly with increased  
salinity.

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LEAKAGE OF UV-ABSORBING SOLUTES FROM SALT-AFFECTED ROOT TIPS  
OF PISTACHIO ROOTSTOCKS

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Excised root tips from 3-year-old pistachio rootstock  
(*Pistacia atlantica* Desf., *P. terebinthus* L., and *P. integer-  
rima* Stewart  $\times$  *atlantica*) were exposed to laboratory saline  
solutions for 24 hr. Treatments simulated the compositions of  
soil solutions in a previous 2-year study made in outdoor  
lysimeters. Leakage of UV-absorbing solutes, an indication of  
cellular damage, occurred with 175 mM Na/12.5 mM Ca, which was  
comparable to soil salinity which increased leaf Na concentra-  
tions and decreased root growth of these species. five  
times higher leakage occurred from roots of a *P. terebinthus*  
genotype having least Na exclusion potential during  
the lysimeter study. Use of isotonic levels of  $\text{CaCl}_2$ , man-  
nitol, and simulated Na/Ca solutions resulted in similar  
damage. However, isotonic Na (-Ca) caused highest leakage  
overall. Correlation between long-term observations in the  
lysimeters and leakage occurrence in the laboratory indicates  
that solute leakage tests may aid in characterizing responses  
of *Pistacia* spp. roots to saline conditions.

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ROOT HARDINESS OF GRAPE CULTIVARS

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Roots of one year old grape cvs. Concord, White Riesling,  
Grenache and Semillon were frozen to 0, -5, -10, -15 and  
-20°C in a programmable freezer. The tops were protected  
from cold by insulating them. For survival test, 4 plants  
of each cv. were planted in the greenhouse and their growth  
observed. Differential thermal analysis (DTA), using a com-  
puter attached to a programmable freezer was performed  
on roots. To aid in the interpretation of DTA, triphenyltet-  
razolium chloride (TTC) was performed. Hardiness determina-  
tions were based on DTA, TTC and the survival tests.  
Patterns representing exothermic response showed an exotherm  
associated with extracellular free water in tissue which  
appeared at about the same temperature range for all cvs.  
This is not associated with hardiness. Additional minor  
exotherms related to hardiness appeared at lower tempera-  
tures than the extracellular water exotherm. Their location  
differed from one cv. to another. Based on these tests,  
Concord roots appear to be harder than other cvs. with  
important but minor differences in the hardiness of other cvs.

# ELEVATED MICROSPRINKLER BENEFITS CITRUS TREES IN A SEVERE ADVECTIVE FREEZE

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Undertree microsprinkler irrigation has protected 1 or 2 year old trees to a height of 1 meter during severe advective freezes. During the severe December 1989 freeze, microsprinklers elevated to 0.9 meter protected 5 year old citrus trees to a height of 2 meters. Limb breakage due to ice loading was negligible. Protection was achieved with water application rates less than half that required by some overhead sprinkler models. Survival is attributed to 1) continuous spray from the microsprinkler rather than periodic spray from a rotating overhead sprinkler, and 2) effective localized application rate on branches intercepting spray is more than average overall spray application rate. Elevated microsprinklers provide freeze protection to a greater height and allow for more rapid post-freeze recovery.

# INJURY TO 27 CITRUS CULTIVARS ON 22 ROOTSTOCKS AT ONE-YEAR-OLD EXPERIENCING MINIMUM TEMPERATURE OF -4.4C

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Evaluation ratings of cold injury following a freeze on December 24 & 25, 1989, showed differences among scion cultivars and rootstock. 'Star Ruby' grapefruit (*Citrus paradisi* Macf.) and 'Fallglo' citrus hybrid, a cross of Bower mandarin citrus hybrid × Temple tangor (*C. temple* Hort. ex Y. Tanaka) were the most severely damaged scion cultivars. 'Rohde Red' valencia orange selection 472-11-43, [*C. sinensis* (L.) Osbeck], was the least damaged scion cultivar. Scions budded to Cleopatra mandarin (*C. resnyi* Hort. ex Tan.) and FL 80-18 citrumelo [*C. paradisi* × *Poncirus trifoliata* (L.) Raf.] rootstock were damaged more than on other rootstock. Scions budded to smooth flat seville (*C. aurantium* ?) and *P. trifoliata* × Ridge pineapple sweet orange selection 1573-26 [*C. sinensis* (L.) Osbeck] had the least injury. Analysis comparing replications showed the greatest damage to be in the north side of the planting.

## 87 ORAL SESSION (Abstr. 520-527) CROSS-COMMODITY TISSUE CULTURE III

# CLONAL PROPAGATION OF LIATRIS PYCNOSTACHYA MICHX BY IN VITRO CULTURE OF AXILLARY BUDS

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A method is described for obtaining explants free of bacterial contamination and for clonal propagation by in vitro culture of liatris axillary buds. Axillary bud growth was stimulated by removal of the shoot tips of greenhouse grown stock plants. Prior to using this approach, extreme bacterial contamination occurred when explants were taken from stock plants that had not been decapitated. However, these axillary buds (0.3 - 0.5 cm long) were successfully established free of bacterial contamination when excised, surface disinfested and cultured on Murashige & Skoog (MS) medium supplemented with various levels of benzyladenine (BA) or kinetin and gibberellic acid (GA<sub>3</sub>). The highest number of leaves and greatest shoot length were produced by buds cultured on a medium supplemented with 1.0 mg/l BA plus 1.5 mg/l GA<sub>3</sub>. Shoot number was increased on medium containing 1.0 or 2.0 mg/l BA plus 0.5 mg/l GA<sub>3</sub>. Kinetin significantly increased the leaf number of the buds but there was no effect of kinetin on the shoot length or number. Shoots formed roots in a medium supplemented with 3 mg/l indole-3-butyric acid (IBA) plus 9 mg/l GA<sub>3</sub>. The plantlets were transferred to vermiculite and acclimatized successfully under intermittent mist in a greenhouse.

# IN VITRO SHOOT REGENERATION OF RUBUS PLANTS USING PETIOLES AND INTERNODES.

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An efficient protocol for plantlet regeneration using petioles and internodes of two blackberry cultivars has been developed for use in genetic transformation. Maximum shoot regeneration was induced on MS medium supplemented with 5 µM Thidiazuron (TDZ) and 0.5 µM IBA. Preconditioning the source shoots on 0.5 µM TDZ containing MS medium did increase the number of regenerated shoots/explant, but did not affect the regeneration percentage. The antibiotic, kanamycin, significantly reduced the growth and regeneration of explants at 10 mg/L or higher. In contrast, cefotaxime at 100-500 mg/L increased explant growth and percentage regeneration.

# TISSUE CULTURE OF CUPHEA GLUTINOSA CHAM. & SCHLECHT.

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*Caphea glutinosa* is a herbaceous, low-growing annual, bearing numerous attractive purple flowers and has potential as an ornamental and as a ground cover. Plants exhibit winter hardiness in USDA plant hardiness zone 8. Tissue culture techniques were developed to obtain large numbers of uniform plants. Whole leaf explants (approximately 1.0 cm<sup>2</sup>) callused profusely in MS (Murashige and Skoog, 1962) medium containing 84 mM sucrose, 1% (w/v) Difco Bacto agar and 8.8 µM N<sup>6</sup>-benzyladenine. Shoot formation from calli was observed in the same medium 4 weeks after explanting. Detached shoots were rooted (100%) in half strength MS medium and rooted shoots were transferred to Promix<sup>®</sup> in the greenhouse 2 weeks after rooting. Tissue cultured plants flowered after 60 days in the greenhouse and no phenotypic differences were observed in floral or foliar characteristics.

# THE EFFECTS OF ABSCISIC ACID ON GROWTH AND DEVELOPMENT OF STAGE III ROOTING ARONIA ARBUTIFOLIA (ROSACEAE)

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Stage 2 micropropagules were transferred into woody plant medium supplemented with either 0, 0.1, 1, 10, 100 mg/L ABA (Abscisic acid) and with or without 1 mg/L IBA (Indole-3-butyric acid). Significant decreases in total dry weight and shoot length were observed at 1, 10 and 100 mg/L of ABA regardless of IBA concentration. Leaf area was significantly reduced in all treatments by increasing ABA levels. In the absence of IBA no callus formed but lateral roots developed. Another experiment using ABA levels of 0, 0.1, 0.5 and 0, 1 mg/L IBA was conducted. Total number of roots decreased with increasing ABA levels. Adventitious roots which formed on the stem and roots originating from root primordia were observed in all ABA levels with IBA. Callus did not form in the treatments lacking IBA. Scanning electron microscopy was used to document morphological differences due to ABA. Abscisic acid levels in leaf tissue were assayed using immunological techniques.

# IN VITRO ROOTING OF PINUS STROBUS AND THUJA OCCIDENTALIS 'HETZ'S WINTERGREEN' AS INFLUENCED BY ANTIGIBBERELLIN COMPOUNDS (ANCYMIDOL AND FLURPRIMIDOL).

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Rooting of shoots from in vitro culture of most conifers can be difficult. An antigibberellin, ancymidol, has been shown to promote rooting of in vitro proliferated shoots of asparagus clones, but it has not been tested on conifers. Ancymidol and flurprimidol was tested for rooting on established cultures of Lake States white pine (*Pinus strobus*). Pulse treatments containing 5 µM ancymidol and 0.5 µM NAA gave 43% rooting, while pulse treatment with 0.5 µM NAA resulted in 7% root formation. Flurprimidol also stimulated root formation on white pine shoots, but was less than ancymidol. *Thuja occidentalis* 'Hetz's Wintergreen' formed roots on 87% of in vitro proliferated shoots when

given a pulse treatment with 5  $\mu\text{M}$  ancymidol and 50  $\mu\text{M}$  NAA. Shoots initiated an average of 10 roots after 60 days on vermiculite containing 1/2 liquid MCM medium.

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#### EFFECTS OF MICROPROPAGATION TECHNIQUES ON GROWTH AND DEVELOPMENT OF MINIATURE ROSES.

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An efficient micropropagation system is being investigated to produce low cost and high quality miniature rose plants. Dormant lateral buds of miniature roses were cultured on media containing MS, 30  $\text{g}\cdot\text{l}^{-1}$  sucrose, 8  $\text{g}\cdot\text{l}^{-1}$ , and 25 combinations of NAA and BA. Initial explant growth was achieved on a medium containing NAA at 0.001-0.01 ppm and BA at 0.1 ppm. The highest multiplication rate was achieved when explants were subcultured on a medium containing MS, NAA at 0.01 ppm, BA at 2 ppm, and sucrose at 30  $\text{g}\cdot\text{l}^{-1}$ . Growth was enhanced after culturing when dormant buds had more parental stem tissue. In addition, explants from the lowest two nodes with the shortest internode length exhibited the poorest growth. The higher the photosynthetic photon flux (PPF) (5 to 40  $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ ), the more quickly explants grew and aged. The most optimal PPF for initial growth was 20  $\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ . Subculture microcuttings of one cm or more in length grew vigorously one month after cuttings were dipped in 1000 ppm IBA and placed on a mist bench. Our results indicate that micropropagation of miniature roses has high potential for use in commercial industry.

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#### TISSUE CULTURE PRODUCED STRAWBERRY PLANTS ARE DEFICIENT IN ABSCISIC ACID (ABA).

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In previous abstracts (HortScience 23:707;24:121), ABA when added throughout the in vitro production cycle, reversed the tissue culture-induced rejuvenation of the day neutral strawberry 'Fern'. Compared to benzyl adenine (BA) proliferated plants, ABA treated tissue culture-produced plants flowered earlier and had more adult leaf patterns. In the present study, we analysed endogenous ABA concentrations in the apices and unexpanded leaves of BA treated tissue culture-propagated plants, selved seedlings and propagated adult runner tip plants at 3, 7 and 15 weeks ex vitro, after germination or after runner tip propagation. Using pentadeuterated standards and single ion monitoring, ABA concentrations in tissue culture produced and juvenile seedling plants were significantly lower than adult plants at 3 and 7 weeks. By 15 weeks, only the adult plants were flowering. At 15 weeks, no differences in ABA concentration were significant and all three types flowered.

527

#### BENZYL ADENINE UPTAKE AND METABOLISM DURING PETUNIA SHOOT ORGANOGENESIS

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The uptake and metabolism of exogenous tritium-labelled benzyl adenine was studied during the shoot induction period of petunia leaf explants in tissue culture. Transfer experiments with Petunia 'MD1' leaf explants (1  $\text{cm}^2$ ) on MS media with 2.2  $\mu\text{M}$  BA show that 27% and 100% of the leaf explants are committed to shoot induction on days 6 and 10, respectively. To study BA uptake and metabolism, leaf explants were placed on media containing tritium-labeled BA for 1, 3, 6 and 10 days. BA was taken up from the media on days 1-6. BA metabolizes were analyzed using HPLC, a UV absorbance detector and enzymatic techniques. Metabolites produced include: BA, BAdo, BA 7G, BA 9G, BAdoMP, BAdoDP, BAdoTP and 3 unidentified compounds. BA and BAdo were detected on days 1 and 3 but not during day 6-10, the time of shoot induction. The pool of ribotide metabolites decreased from days 1 to 10, from 26.5% of all metabolites to 1.6%. Glucosylated compounds, BA 7G and BA 9G, increased continuously from 24.9% to 69.8% between days 1 and 10. An unidentified compound C increased from 13% on day 3 to 24.8% on day 10. In separate experiments, BA uptake and metabolism were compared in two Petunia hybrida lines, St40 and TLV1, with different shoot organogenic responses in tissue culture. These data show interesting patterns of BA metabolism in relationship to shoot induction and organogenesis.

## 88 ORAL SESSION (Abstr. 528-533)

### FLORICULTURE: GROWTH AND DEVELOPMENT

528

#### RESPONSE SURFACE REPRESENTATION OF ROSE (ROSA HYBRIDA L.) GROWTH CHARACTERISTICS

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Day (DT) and night temperature (NT), and irradiation (photosynthetic photon flux-PPF) treatment combinations were run from a rotatable central composite design. At flowering, response surfaces were plotted for 'Royalty' rose for plant growth characteristics: node number, stem diameter, stem length, and dry weight of stem, leaves, flower bud, and total shoot. Overall development was recorded from pinch until visible bud, first bud color, and flowering. All characteristics except node number and stem length were significant ( $P=0.05$ ) for a full quadratic model having ten estimated coefficients. Greatest dry weights were predicted at flowering for the lowest DT (15C) and NT (12C) combination, and required the longest time for development. Conversely, most rapid development and least dry weight accumulated for high DT (25C) and NT (22C). Thus, a compromise exists between rapid development and quality of the flowering stem. As PPF increased from 50 to 300  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ , predictions for dry weights increased while developmental time decreased.

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#### LEAF DEVELOPMENT AND ANTHURIUM FLOWER GROWTH

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The *Anthurium andraeanum* 'Kaumana' flower growth and development before and after emergence was studied. The process before emergence was long and slow. A tiny flower bud, about 0.3 cm long was formed 80 days before its emergence. The whole period before emergence was divided into three phases: cell division phase, slow growth phase and elongation phase. The characteristic of each phase was studied.

The leaf which bears the flower bud at its petiole base is called subtending leaf. Its growth had a significant influence on the flower bud growth at its petiole base. Detaching the young subtending leaf blade resulted in an earlier flower emergence.

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#### PHENOLOGY OF FLOWERING IN CULTIVATED *HELICONIA CHARTACEA*

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Although in florescences of *H. chartacea* 'Sexy Pink' can be harvested year 'round in Hawaii, flowering is heaviest during the summer while demand is higher during winter months. The research was directed at identifying influences affecting the timing and rate of flower development. Dissection of apices of pseudostems which began development during June-July showed reproductive development (3-6 cm) in Jan-Feb when @6 leaves had unfurled. Some pseudostems had aborted the growing point after initiation had occurred. Data from 141 flowering pseudostems over 2 years of sampling showed that approx. 46 weeks were required from shoot emergence to flowering. Seasonal variation existed for leaf number and developmental period. The paper will analyze the influence of temperature on these two components of flowering.

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#### ROLE OF CARBOHYDRATE DEPLETION AND ETHYLENE IN FLOWER BUD ABSCISSION OF *HIBISCUS ROSA-SINENSIS* L.

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Premature flower bud abscission imposes a serious limitation on longevity of potted *Hibiscus* in interiorscape situations. Ethylene is known to be one causative factor. Past research has suggested that carbohydrate depletion of buds may also be involved.

A series of experiments was conducted to examine the relationship between carbohydrate levels and ethylene sensitivity of flower buds under low irradiance levels. Two cultivars were used: 'Pink Versicolor', which is very susceptible to bud abscission, and the more resistant 'Vista'. In the first experiment, plants were harvested twice weekly after placement in

interiorscape rooms (8.5  $\mu\text{mol m}^{-2}\text{s}^{-1}$  for 12 hrs per day; 26.5°C day/night) until all buds had abscised. At each harvest, buds from four size groups were collected for analysis. In the second experiment, source/sink strength of buds was manipulated by selective daily removal of certain sized buds. Remaining buds were collected just prior to abscission for analysis. In two additional experiments, 'Pink Versicolor' plants were treated with either silver thiosulfate or ethephon prior to placement in interiorscape rooms. Plants were harvested twice weekly and buds collected. For all experiments, bud dry wt, total soluble sugars and starch content were determined.

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#### POSTHARVEST CONTROL OF *BOTRYTIS CINEREA* INFECTIONS ON CUT ROSE FLOWERS WITH PYRROLNITRIN.

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Pyrolnitrin, an antibiotic isolated from *Pseudomonas cepacia*, was used for postharvest control of *B. cinerea* infections on cut 'Sonia' and 'Royalty' rose flowers. Pyrolnitrin was applied as a bud dip and followed by inoculation with *B. cinerea* conidia. Dip treatments of 12 to 200 mg-liter pyrolnitrin significantly reduced disease severity during storage at 2°C and promoted post-storage fresh weight gain (an index of cut flower quality). No phytotoxicity was observed on leaves or petals at concentrations of up to 200 mg/liter. Dip treatment with 100 mg/liter pyrolnitrin reduced disease severity to <10% of that on control flowers and prevented post-storage flower rot. This level of disease control was comparable to that achieved with 1800 mg/liter vinclozolin.

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#### CONTROL OF *ERWINIA CAROVORA* (AROIDEAE) ON *ZANTEDESCHIA* Marihelen Kemp-Glass\*, North Carolina A&T State University, Greensboro, NC 27411

A major problem in the pot production of *Zantedeschia* (Calla Lillies) is the bacterial soft rot *Erwinia carotovora*. Sometimes if the corn is infected there may be no symptoms until the plant falls over. This disease can destroy an entire crop very quickly. *Z. albomaculata*, *Z. Elliottiana*, *Z. Solfatare*, and *Z. rehmannii* were soaked for 5 minutes and 10 minute in 50 ppm and 100 ppm respectively in Agrox Strep a combination bactericide and fungicide. The 50 ppm for 5 minutes gave sufficient control of soft rot provided the plants were not over-watered. However, if overwatered the incidence of soft rot did reoccur. This was controlled by watering the plants every 10 days with 50 ppm of Agrox Strep.

## 96 ORAL SESSION (Abstr. 534-541) FRUIT CROPS: POSTHARVEST PHYSIOLOGY I

534

#### MODIFIED ATMOSPHERE PACKAGING: TEMPERATURE DEPENDENCE OF THE RQ "BREAKPOINT"

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The steady-state oxygen concentration at which blueberry fruit began to exhibit anaerobic carbon dioxide production (i.e., the RQ breakpoint) was determined for fruit held at 0, 5, 10, 15, 20 and 25°C using a modified atmosphere packaging (MAP) system. As fruit temperature decreased, the RQ breakpoint occurred at lower oxygen concentrations. The decrease in the RQ breakpoint oxygen is thought to be due to a decreasing oxygen demand of the cooler fruit.

The decrease in oxygen demand and concomitant decrease in oxygen flux would have resulted in a decrease in the difference in the oxygen concentration between the inside and outside of the fruit and thus decreased the minimum amount of oxygen tolerated. The implications on MAP strategies will be discussed.

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#### APPLICATION OF MODIFIED ATMOSPHERE PACKAGING AND HUMIDITY CONTROL TO EXTEND THE STORAGE LIFE OF GRAPE VARIETIES GROWN IN EASTERN UNITED STATES - A COMPARATIVE STUDY

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In 1987, 1988, and 1989, the behavior of four different table grape varieties including Alden, Concord, Himrod, and Vanessa were studied during storage at 0°C.

The first objective of our study was to determine the behavior of table grapes in modified atmosphere packages in terms of general acceptance. After three years of experimenting with these three films we were able to obtain a modified atmosphere of about 3% O<sub>2</sub> and 10-15% CO<sub>2</sub> at 0°C using a 3 mil thickness LDPE.

Our second objective was to use moisture absorbents as a means of reducing the relative humidity inside the void volume of a package by the inclusion of different desiccants in the package to establish a desirable relative humidity.

Examining different storage characteristics, our data showed that 'Himrod', 'Vanessa', and 'Concord' grape clusters stored in the presence of KNO<sub>3</sub> and KCl had better quality compared to grape clusters stored in the presence of other sorption compounds or controls with no sorbants.

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#### EFFECT OF PREHARVEST CULTURAL PRACTICES ON STORAGE LIFE OF GRAPE VARIETY 'HIMROD'

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The grape variety 'Himrod' under conventional storage practices has a short storage life while it has an excellent quality character.

To modify berry size and cluster compactness, different treatments are being used. Application of these cultural practices has pronounced effect on storage life of grapes. The cultural practices consist of different combinations of gibberellin application (two different concentrations), girdling and cluster thinning.

Biophysical and biochemical evaluation of the grapes under two different modified storage conditions showed that treated grapes react differently during storage. Our results suggest that grapes that were only treated with gibberellin (20 ppm at shatter and 50 ppm postshatter) were better than control than any other combined treatments and the worst was the case of only girdling application. Combination of these two treatments were intermediate in terms of biophysical evaluation.

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#### FUMIGATION OF TABLE GRAPES WITH DECCODIONE SMOKE TABLETS FOR PROLONGING THE POST HARVEST STORAGE LIFE

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Table grapes cvs. Flame Seedless, Black Monukka and Canadice were fumigated with 2 levels of Deccodione smoke tablets for 30 minutes. Grapes were packed in TKV lugs with *Botrytis* inoculum planted among the clusters and stored at 0°C for up to 9 weeks. Size of smoke particles was determined. Fruit was evaluated at weekly intervals for decay and quality parameters. Deccodione residues on fruit were determined and found to be within acceptable limits set for this chemical. It was possible to store the grapes for up to 4 weeks at 0°C in good condition. Beyond this period effect of fumigation was lost. There was no bleaching of pigments around the capstem as is seen with sulfur dioxide fumigation. Storage for prolonged periods will necessitate increasing the dose of Deccodione tablets and/or repeating the fumigation.

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#### EFFECTS OF MOIST HEAT TREATMENTS ON THE POSTHARVEST BEHAVIOR OF 'CHANDLER' STRAWBERRY

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Three successive experiments were included in this trial. The first experiment was a detailed screening program to test the effects of various temperatures and durations on the fruit quality of strawberry fruit. Fruit were exposed to temperatures of 37, 40, 43, and 46°C for durations of 20, 40, 60, 80, and 100 minutes at each temperature level. The temperatures

and durations which were detrimental to fruit quality were eliminated; then experiments 2 & 3 were conducted using the remaining temperature and duration levels to study their effects on fruit quality, respiration, and ethylene production.

Strawberries heated to 46° C were too severely damaged for other test comparisons. Those exposed to temperature treatments of 43 °C for 30 or 60 mins were consistently less firm, had more heat damage, developed less decay, and had lower CO<sub>2</sub> and ethylene production than fruit from lower temperature treatments or control fruit. Differences were sometimes significant.

While the heat damage scores from fruit exposed to the 43°C treatments indicated some serious injury, the fruit were stiff judged to be marketable. There were no significant differences in soluble solids content (SSC), titratable acidity, SSC/acid ratio, or juice pH among any of the treatments.

5 3 9

#### PACKINGHOUSE EFFECTS ON WATER LOSS, SPOILAGE, JUICE, AND PEEL QUALITY OF TEXAS GRAPEFRUIT

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Advertisers endow Texas grapefruit with perennial, uniform excellence, yet prices reflect quality variation in the packed product. This study attempts to determine which packinghouse operations, if any, contribute to this variation. Sixty marked 'Ruby Red' grapefruit were run through each of 5 Rio Grande Valley packingsheds. Sample runs were made in Dec., Jan., Feb., and Mar. for two seasons. Within-sample variation was reduced by picking outside canopy fruit from the same 20 trees. After packingshed treatment, weekly water loss was determined over 30 days storage at 22 C. and 70% R.H. Then fruit juice and peel were evaluated. Water losses varying from 6-8% appeared related more to initial differences between sheds than to rate of loss in storage. Water loss was greatest for March-and lowest for January-harvested fruit with Dec. and Feb. intermediate. Packingsheds had no effect on fruit spoilage. While some differences between juice (e.g., %) and peel (e.g., strength) characteristics were associated with water loss, season and harvest date caused the greatest variation.

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#### INFLUENCE OF DRYING AIR VOLUMES ON FATTY ACID COMPOSITION OF PECANS

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'Stuart' pecans were harvested as soon as shucks would split in the fall of 1989 and 45 kg inshell samples were placed in 30 × 30 × 105 cm drying bins. The nuts were dried at air volumes of either 0, 1.27, 1.56, 1.84, or 2.12 m<sup>3</sup>/min down to 4% moisture. Air temperature in the drying bins was maintained at uniform 35°C with the exception of the 0 air volume treatment which was allowed to dry at room temperature. Four random samples of each treatment were held in frozen storage awaiting fatty acid analysis. Palmitic, stearic, oleic, linoleic, and linolenic fatty acids were separated in a 183 cm × 3 mm packed column using a 10% Silar 10C phase on a Gas Chrom QII, 100/120. The samples dried with a air volume of 1.27 m<sup>3</sup>/min retained a significantly higher oleic acid content than the 0 and 2.12 m<sup>3</sup>/min drying volumes. The 1.27 m<sup>3</sup>/min volume retained 64.55 % oleic acid compared with 61.37% for the 0 velocity sample and 59.61% for 2.12 m<sup>3</sup>/min treatment. The more desirable oleic/linoleic ratio of 2.24 was found in the 1.27 m<sup>3</sup>/min sample compared to a 1.78 ratio in the 2.12 m<sup>3</sup>/min sample. Increased volume of air in the drying bins was thus deleterious to these samples because of the loss of monounsaturated fatty acid.

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#### EFFECTS OF INSECTICIDAL LOW-OXYGEN ATMOSPHERES ON POSTHARVEST PHYSIOLOGY AND QUALITY OF STONE FRUITS

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Fruits of peach (*Prunus persica* L., cv. 'Fairtime') and plum (*Prunus domestica* L., cv. 'Angeleno') were kept in air and in 0.25% or 0.02% O<sub>2</sub> at 0, 5, or 10°C for 3 to 40 days to study the effects of temperatures and insecticidal low O<sub>2</sub> atmospheres on their physiological responses and quality attributes. Exposure to low O<sub>2</sub> atmospheres reduced respiration and ethylene production rates of the stone fruits. The low O<sub>2</sub> treatments retarded color change and flesh softening of plums and maintained acidity of peaches. Exposure to the low O<sub>2</sub> atmospheres also delayed incidence and reduced severity of internal breakdown (chilling injury) and decay of the peaches at 5°C and, therefore, maintained both external and internal appearance qualities of the fruits longer than those kept in air. The most important limiting factor for fruit tolerance to insecticidal low O<sub>2</sub> atmospheres was development of alcoholic off-flavor

which was associated with accumulation of ethanol and acetaldehyde in the fruits. The peaches and plums could tolerate exposures to the low O<sub>2</sub> atmospheres for 9 to 40 days, depending on the temperature and O<sub>2</sub> level used. These results suggest that stone fruits are quite tolerant to insecticidal low O<sub>2</sub> atmospheres.

## 97 ORAL SESSION (Abstr. 542-548) VEGETABLE CROPS: GROWTH AND DEVELOPMENT

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EARLY TRANSPLANT GROWTH IN RELATION TO FRUIT YIELD IN TOMATO  
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Tomato, cv. 'Sunny' containerized transplants produced either with overhead (SP1) or sub (flotation) (SP2) irrigation were established in the field in fall, winter, and spring. Leaf area (LA), root volume (RV), and dry weights of shoots (SDW) and roots (RDW) were measured weekly before and after transplanting. In fall 1987, SP1 with 44 cm<sup>2</sup> LA, 275 mg SDW, 68 mg RDW, and 0.9 ml RV at transplanting (T<sub>0</sub>) had 33% more fruit yield than SP2 transplants with 20 cm<sup>2</sup> LA, 236 mg SDW, 62 mg RDW, and 0.6 ml RV at T<sub>0</sub>. In spring and winter 1988, SDW, RDW, and RV increased uniformly in both SP1 and SP2 plants, and yields did not differ significantly. In spring 1989, at T<sub>0</sub>, SP1 had 182 mg SDW and 7.8 shoot/root ratio (S:R) and SP2 had 92 mg SDW and 4.6 S:R, thereafter SDW and S:R ratios were not different and yields were unaffected. In fall 1989, SP1 total fruit yield (52.3 t.ha<sup>-1</sup>) did not differ significantly from that of SP2 (47.4 t.ha<sup>-1</sup>) plants. Sub irrigated transplants may have similar fruit yields than overhead irrigated transplants provided plants are kept with minimum stress before establishment.

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#### GROWTH STUDIES WITH SNAP BEANS TO PREDICT HARVEST

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Studies were initiated in 1989 to characterize phenological events with corresponding growth and development phenomena of 'Eagle' and 'Provider' snap beans (*Phaseolus vulgaris* L.) Ten plantings at approximately 15 day intervals were made at Knoxville, TN from April 17 through July 27. Days to reach growth stages V<sub>0</sub> thru R<sub>0</sub> were recorded for each cultivar for each planting date. Air temperature, total radiant energy, wind speed and relative humidity were recorded hourly throughout the 171 day test period. Growing degree days (GDD) computed by 8 methods and growing degree hours (GDH) computed by 2 methods were regressed against plant developmental stages. GDD and GDH, along with pod size and pod fiber content, will be discussed as possible indices for predicting harvest maturity. With the methods used to calculate heat summation in this study, GDD and GDH from planting to pod maturity ranged from approximately 550 to 975 and 9,700 to 20,000, respectively.

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#### YIELD AND POD DISTRIBUTION OF CAYENNE PEPPERS AS AFFECTED BY PLANTING DENSITY

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The effect of planting density on yield and pod distribution of cayenne pepper (*Capsicum annuum* var. *annuum* L. cv. Carolina Cayenne) was investigated in a two year study. In 1988, planting density was adjusted by altering the in-row spacing of single row beds, while in 1989 planting density was adjusted by altering both in-row spacing and number of rows per bed. In-row spacings evaluated in 1988 were 60, 45, 30, and 15 cm, while in-row spacings of 60, 30, and 15 cm in single and double rows were evaluated in 1989. In 1988, pepper plants grown in the highest density (15 cm in-row spacing) produced less fruit per plant, but more fruit per hectare than those grown in lower densities. In 1989, greatest yields per hectare were recorded with either 15 cm in-row spacings with single rows per bed or 30 cm in-row spacings with double rows per bed. In general, greater percentages of fruits were located in the upper part of the plant canopy when planted in higher plant densities.



# INTERACTIVE EFFECTS OF INCREASED CO<sub>2</sub> AND TEMPERATURE ON GROWTH PARAMETERS, GAS EXCHANGE RATE AND SEED YIELD OF RICE.

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Proponents of global climate models predict a doubling of world CO<sub>2</sub> concentration from 350 to 600 ppm by the year 2030, concurrent with a 2-5°C temperature increase. Consequences of this "greenhouse effect" on *Oryza sativa* L. were determined using four rice lines selected for their widespread use in cultivation and research. A 2x2 factorial design was used with CO<sub>2</sub> at 350 and 600 ppm and day/night temperature regimes of 31/27°C and 37/33°C. Combined effects of CO<sub>2</sub>/temperature were determined during 5 harvests from seeding to reproductive maturity. Elevated CO<sub>2</sub> enhanced dry weight and photosynthetic capacity over both temperature regimes relative to plants grown at ambient CO<sub>2</sub>. The 37/33°C day/night temperature regime increased sterility in rice by decreasing pollen shed.

# ATMOSPHERIC CO<sub>2</sub> ENRICHMENT OF TOMATO AND STRAWBERRY PLANTS UNDER FIELD PRODUCTION CONDITIONS

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A technique was developed for controlled micro-release of CO<sub>2</sub> into the leaf canopy of strawberry and tomato plants under field production conditions. The leaf canopy atmosphere of tomato plants was enriched to 500 and 1200 ppm CO<sub>2</sub> with release rates of 60 and 300 l/h·30m of row respectively. After 60 days of enrichment for 6 h each day beginning at fruit set, the total shoot biomass and yield was increased 41% and 25% respectively for the high CO<sub>2</sub> release rate. Strawberry leaf canopies did not show increased CO<sub>2</sub> levels with CO<sub>2</sub> enrichment except under ventilated row-covers where the atmospheric CO<sub>2</sub> level was increased to 1500 ppm CO<sub>2</sub>. Although the total biomass was increased 39% this did not translate into increased yields perhaps due to excessive temperatures under the row covers.

# SUGAR ACCUMULATION IN FRUIT OF CULTIVATED AND WILD SPECIES OF TOMATO

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Sugar accumulation throughout fruit development in the cultivated tomato (*Lycopersicon esculentum*) and a wild green-fruited species (*L. peruvianum*) are being examined. Results obtained using HPLC demonstrate that the fruit of *L. peruvianum* accessions accumulate the disaccharide, sucrose, in addition to the monosaccharides, glucose and fructose, common to *L. esculentum*. When detectable, sucrose in the *L. esculentum* cultivar FM6203 was present at very low levels throughout development. Analysis of mature fruit of *L. esculentum* var. *cerasiforme*, *L. pimpinellifolium*, and *L. cheesmanii* accessions indicate glucose and fructose as the primary storage sugars. Similar to *L. peruvianum*, mature fruit of the green-fruited species, *L. hirsutum* f. *typicum* and *L. hirsutum* f. *glabratum*, accumulate sucrose in addition to glucose and fructose.

# THE INFLUENCE OF LIGHT ON TOMATO FRUIT GROWTH AND METABOLISM

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Light/dark effects on growth and sugar accumulation in tomato fruit were studied on intact plants (in vivo) and in tissue culture (in vitro). Similar patterns of growth and sugar accumulation were found in vivo and in vitro. Fruit growth in different sugar sources (glucose, fructose or sucrose) showed that sucrose was the primary carbon source translocated into tomato fruit. Darkening the fruit decreased growth about 40% in vivo and in vitro. Light-grown fruit took up 30% more sucrose from the same source and accumulated almost twice as much starch as that in dark-grown fruit. The difference in CO<sub>2</sub> exchange rate between light and dark indicated that light effects on fruit growth were due to mechanisms other

than photosynthesis. Supporting this conclusion was the fact that light intensities ranging from 40 to 160 µmol/m<sup>2</sup>/s had no influence on growth and light did not increase growth when fruits were grown on glucose or fructose. A possible expansion of an additional sink for carbon by light stimulation of starch synthesis during early development will be discussed.

## 98 ORAL SESSION (Abstr. 550-557) CROSS-COMMODITY GENETICS I

# CHARACTERIZATION OF CUCURBITA ARGYROSPERMA, A POTENTIAL NEW CROP FOR SEED AND FRUIT PRODUCTION

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*Cucurbita argyrosperma*, formerly known as *C. mixta*, is a squash species native to Mexico and Central America. Cultivars of the species which have been grown in the United States include many of the cushaws and the 'Silverseed Gourd'. A recent biosystematic analysis—which included studies of experimental and natural hybridization, isozymatic and morphological variation, ethnobotany, and ecological and geographical distribution—has shown that the closest relative of *C. argyrosperma* is *C. moschata*. The data reveal intriguing implications for evolution of the genus as a whole, since the previous hypothesis that *C. lundelliana* is the progenitor of *C. moschata* is refuted. A wild ancestor, three cultivated varieties and a feral derivative are recognized within *C. argyrosperma*. Two of the three cultivated botanical varieties—vars. *argyrosperma* and *stenosperma*—have been selected in many regions almost exclusively for seed production. The relatively large seeds are marketed either with or without hulls. The other botanical variety, var. *callicarpa*, has been selected for both fruit and seed production. Northern cultivars of var. *callicarpa* are notable for their adaptation to marginal environments, including hot climates and poor soil conditions.

# COLLECTION OF FRAGARIA IN CENTRAL AND SOUTHERN CHILE

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In January, 1990, a team of U.S. and Chilean scientists collected native and cultivated *Fragaria* from central and southern Chile. During the course of this expedition, 363 new accessions of *Fragaria* were collected. Approximately 2,500 plants of 250 clones were collected from 66 sites in 19 different areas, and 113 seedlots (estimated at over 100,000 seeds) were obtained.

Plants were collected from a wide range of habitats, and considerable variability was observed in vegetative and reproductive characteristics. Fruit were round to conical in shape, deep red to white in color, soft to moderately firm, with soluble solids ranging from 5-18%, dull to glossy skin, bland to strong flavor, low to very high aromatics, and difficult to moderately easy capping. Fruit size *in situ* approached 4 g, while fruit larger than 12 g were found under cultivated conditions. Strawberry aphids (*Chaetosiphon fragaefolii*) were found on plants *in situ* and under cultivation. Little or no evidence of other pests were observed on clones collected *in situ*.

# FRAGARIA GERMLASM FROM MINNESOTA AND WISCONSIN

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Introgression of *Fragaria vesca*, the diploid wild strawberry, and *F. × ananassa*, the octoploid cultivated strawberry, into octoploid *F. virginiana* collected from Minnesota and Wisconsin was suggested by gynodioecy and cluster analysis. Nine morphological traits separated collections into two main clusters, one associated with the northern hardwoods, and the other in the prairie-forest floristic province. Under field conditions, wild female clones were rated similarly to check cultivars for fruit set and plant productivity but always significantly higher than wild hermaphrodites. Increases in yield might be gained by selecting female clones for incorporation into a breeding program. Breeders anticipating rapid transfer of traits from the wild might concentrate on collections from the prairie-forest floristic province, since these materials contain *F. × ananassa* traits. Maximum genetic diversity would be gained using collection from both floristic provinces.

THE STATUS OF *PYRUS* GERMPLASM IN THE US

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*Pyrus communis* L. germplasm came to North America with early settlers. *Pyrus* cultivars have markedly declined since the turn of the century when more than 2700 unique *Pyrus* cultivars and 10,000 cultivar synonyms were noted. In 1956, 844 *Pyrus* cultivars and selections were widely available. Fireblight, *Erwinia amylovora* (Burril) Winslow et al. 1923, and lack of cold hardiness were main causes of cultivated germplasm loss. During June through December 1989, I resurveyed 37 State Agricultural Experiment Stations which had pear collections in 1956, to determine the present extent of their collections. Only four had more than 100 cultivars; 12 had 10 to 100 cultivars; 21 had less than 10. Experiment stations have decreased their collections because of funding cuts and program redirection. The National Clonal Germplasm Repository at Corvallis, established in 1981, has a collection of 811 unique cultivars and representatives of 26 *Pyrus* species. About 194 cultivars published in 1908 are in the NCGR collection. At least 424 of those listed in 1956 still exist. Oriental species and other foreign selections not previously available are actively being acquired. About 80% of the clones in the NCGR collection are virus negative; about 10 % reside in backup in vitro storage. Fireblight damage has not been observed thus far. With continued federal support, *Pyrus* germplasm availability should remain more stable than the decline seen in the last 90 years.

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## EX SITU PRESERVATION, MAINTENANCE, AND EVALUATION OF VIRUS-FREE CLONAL CITRUS GERMPLASM

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The USDA-ARS National Clonal Germplasm Repository for Citrus is establishing a virus-free clonal collection of 830 citrus germplasm accessions at its Riverside, California facility with the objective of reducing genetic vulnerability of citrus and providing virus-free clonal germplasm to researchers worldwide. Accessions in the collection are evaluated for trueness-to-type using leaf isozymes and are characterized for 58 descriptors. Research is expanding into RFLPs for development of a usable genomic map and cultivar-specific probes. Citrus seed, pollen and buds are being investigated for extended preservation under low temperatures and cryostorage. Preliminary data is promising but indicates considerable variability between cultivars. In-vitro culture of excised embryo tissue is being investigated. A comprehensive pathogen detection program is underway. Infected accessions receive shoot-tip micrografting and thermotherapy treatments to eliminate pathogens. Accessions are maintained as potted trees in greenhouse or aphid-proof screenhouses. A complete computer based record is maintained for each accession on site and in the USDA-ARS GRIN database.

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## THE USE OF DORMANT-BUD CRYOPRESERVATION FOR LONG-TERM STORAGE OF PECAN AND WALNUT GERMPLASM

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A study was designed to determine if current dormant-bud cryopreservation techniques investigated on woody plants, such as apple (*Malus domestica*), gooseberry (*Ribes*), blueberry (*Vaccinium corymbosum*) and pear (*Pyrus communis*) etc., could be applied to certain nut tree species for long-term preservation. Pecan (*Carya illinoensis*) and black walnut (*Juglans nigra*) were exposed to prefreezing temperatures ranging from -10° C to -40° C and then directly immersed in liquid nitrogen for 2 hrs. Dehydration by prefreezing was not sufficient for bud survival in pecan. Bud survival was increased by dehydrating stem sections prior to prefreezing. Prefreezing at -30° or -40° C was suitable for survival of black walnut.

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## INTERSPECIFIC HYBRIDIZATION OF ORNITHOGALUM

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Three species of *Ornithogalum* are extensively grown. They are *O. umbellatum*, *arabicum* and *thyrsoides*. All three have white flowers. Another species, *O. dubium*, has deep

orange flowers, but produces a weak inflorescence. Hybrids have been produced within a species but no wide crosses have been reported. Embryo rescue was successfully applied to develop new hybrids between *O. dubium* with strong color and *O. thyrsoides* with a strong inflorescence. The F1 hybrids produced buff-colored flowers on strong inflorescences with short internodes and long strong pedicels. The meiosis of these hybrids was not normal with univalent, laggards and bridges present. The F1 hybrids were slightly fertile and F2 and backcross progeny were produced. The progeny showed considerable segregation for both flower color and inflorescence traits. Clones were obtained which combined the orange flower colors of *dubium* with the strong inflorescence of *thyrsoides*.

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## BREEDING OF NEW HIPPEASTRUM CULTIVARS USING DIPLOID SPECIES: THE F-1 EVALUATION.

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An amaryllis breeding program using diploid species not represented in commercial tetraploid cultivars has been underway since 1988. Objectives are to develop evergreen cultivars with attractive foliage and fragrant flowers of novel form and coloration. Five crosses with *Hippeastrum papilio* as a parent were evaluated at first flowering in the spring of 1990. The F-1's showed significant variation, suggestive of high heterozygosity within the parental genomes. Several natural tetraploids were identified among the progeny. Superior selections were made, and sib- or intercrosses accomplished. We estimate that a minimum of 50% genes from *H. papilio* will need to be maintained to guarantee evergreen foliage in the progeny. Superior F-1's have also been crossed with fragrant, trumpet-flowered primary hybrids, and new primary F-1's are being generated with *H. papilio* and these species or their hybrids, as well as with *H. reticulatum* var. *striatifolium*. A percentage of these germinated seedlings have been treated with colchicine to induce polyploidy. The best F-1 selections are also being micropropagated, and induction of polyploidy will be attempted in a percentage of the subcultures.

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## 99 ORAL SESSION (Abstr. 558-565)

### WOODY PLANT STRESS PHYSIOLOGY

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## PRUNING EFFECTS ON COLD HARDINESS OF TWO WOODY ORNAMENTAL PLANT TAXA

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The effects of timing of pruning in relation to cold hardiness of *X Cupressocyparis leylandii* (A. B. Jacks. and Dallim.) Dallim. and A. B. Jacks. 'Haggerston Grey' and Lagerstroemia L. 'Natchez' were evaluated on 6 test dates from August 1989 to March 1990. Pruning treatments decreased the cold hardiness of both taxa compared to unpruned controls on 5 test dates. Cold tolerance of 'Haggerston Grey' decreased for 4 to 5 months following the August and October pruning compared to the unpruned controls. 'Haggerston Grey's cold tolerance were reduced by 6C in February. October and December pruning of 'Natchez' reduced cold hardiness by 4C in January. However, cold hardiness of January and February pruning treatments was similar to unpruned controls. In general, the data indicated that plants of 'Haggerston Grey' pruned in October through February were less cold hardy than plants pruned in August. Ideally, 'Natchez' crape myrtle should be pruned in late winter.

# THE RELATIONSHIP OF NEAR-LETHAL STRESS ON DORMANCY AND COLD HARDINESS

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In previous work, we have shown that near-lethal heat stress can overcome dormancy in Red-osier dogwood, *Cornus sericea* L. The objective of this study was to determine the effects of premature breaking of dormancy on the development of cold hardiness. Plants at three stages of dormancy (early, deep, and late) were exposed to 47C for one hour and then placed into 3 post-treatment environments (0C, 23C, and natural conditions). At periodic time intervals, the plants were evaluated for bud break, cold hardiness, and stem injury. These studies suggest that premature breaking of dormancy at the early stage had no effect on hardiness development, whereas at the deep and late stages of dormancy, premature breaking of dormancy caused a faster rate of deacclimation at the warmer post-treatment environments. In addition, we observed that the heat-treated plants died during storage at 0C, and survived at 23C storage and natural conditions.

# WEEKLY COLD HARDINESS LEVELS OF SEVEN DECIDUOUS HARDWOODS OVER THREE WINTER SEASONS

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The cold hardiness of seven deciduous hardwoods, red maple (*Acer rubrum* L.), white oak (*Quercus alba* L.), green ash (*Fraxinus pennsylvanica* Marsh.), sweetgum (*Liquidambar styraciflua* L.), sugar maple (*Acer saccharum* Marsh.), river birch (*Betula nigra* L.) and black cherry (*Prunus serotina* Ehrh.) were evaluated weekly during the fall, winter and spring for three consecutive years. All trees evaluated were established (20-40 years old) and located at the Georgia Station Griffin, GA. Each species developed a maximum cold hardiness of at least -30 C by mid-January or early February each season. Response to temperature fluctuations varied with species. Red maple, for example, lost less cold hardiness due to warm mid-winter temperatures than the other species tested, while white oak tended to respond more quickly to the temperature fluctuations. Data will be presented comparing the response of cold hardiness to mid-winter temperature fluctuations for each species for the three year period.

# EFFECT OF SUPRAOPTIMAL TEMPERATURES ON ROOT RESPIRATORY CHARACTERISTICS OF 'ROTUNDIFOLIA' HOLLY

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Respiration of excised *Ilex crenata* 'Rotundifolia' roots as influenced by root-zone growth temperature and buffer solution temperature was measured in the presence and absence of SHAM and KCN. Respiration rates of roots excised from plants grown for three weeks at root-zone temperatures of 30, 34, 38, and 42 C decreased linearly as root-zone temperature increased when the buffer solution was maintained at 25 C. When the buffer solution temperature was the same as the root growth temperature, no differences in respiration rate were found. When plants were grown at a root-zone temperature of 30 C, respiration was maximal at 34 C and decreased to a minimum at 46 C. Above 46 C, stimulation of O<sub>2</sub> consumption occurred which was presumed to be extra-mitochondrial. CN-resistant pathway activity decreased at a buffer solution temperature of 46 C which was similar to the critical threshold temperature (48±1.5 C) for 'Rotundifolia' holly roots.

# HONEY LOCUST SEEDLING DEVELOPMENT DURING OSMOTIC AND HIGH ROOT TEMPERATURE STRESS

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Development of half-sib *Gleditsia triacanthos inermis* Willd. (honey locust) seedlings was studied during exposure to osmotic and high root temperature stress. Seven days after seed scarification, seedlings of uniform fresh weight were transferred to static hydroponic culture vessels in a growth chamber. Three days later, vessel solutions were replaced with polyethylene glycol 8000-

amended solutions with osmotic potentials ( $\psi_s$ ) of -0.05, -0.10, or -0.20 MPa at 23C. Within each  $\psi_s$  treatment, root temperature was increased from ambient (23C) to 35C for 0, 6, 12, or 24 hr day<sup>-1</sup> for 20 days. Root and shoot dry weights decreased with increasing exposure to 35C among seedlings in the -0.05 MPa solution and decreased for seedlings in -0.10 and -0.20 MPa solutions in all temperature regimes. Epicotyl expansion tended to decrease with decreasing  $\psi_s$  and increasing exposure to 35C. However, for plants in the -0.20 MPa solution, epicotyl length was greatest when roots were exposed to 35C for 6 hr day<sup>-1</sup>.

# HEAT TOLERANCE AND ETHYLENE PRODUCTION IN RED-OSIER DOGWOOD STEM TISSUES AT DIFFERENT GROWTH STAGES

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Red-osier dogwood stems, *Cornus sericea* L., at ten different growth stages were subjected to a series of temperatures ranging from 25C to 60C by immersing them in a water bath for one hour. After heat treatments, the viability of internode tissues were determined by electrical conductivity and ethylene production. Heat tolerance was expressed as LT<sub>50</sub>, the temperature at which 50% of the tissues were injured. The results suggest that the LT<sub>50</sub> of dormant plants remained relatively constant, approximately 53C. During dormancy, heat stress did not stimulate ethylene production from internode tissues. In contrast, tissues from non-dormant plants exposed to heat stress produced increasing levels of ethylene reaching a peak at 40C followed by a steady decrease at higher temperatures. Application of 1-aminocyclopropane-1-carboxylic acid (ACC) to stem segments from dormant plants, following heat treatment, enhanced production of ethylene.

# COMPARATIVE DROUGHT RESISTANCE AMONG SIX BIRCH (BETULA) SPECIES

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In order to evaluate and compare adaptability to dry sites, plant water relations and leaf gas exchange were compared in response to water stress among six birch species: monarch birch (*Betula maximowicziana*), river birch (*B. nigra*), paper birch (*B. papyrifera*), European birch (*B. pendula*), 'Whitespire' Japanese birch (*B. platyphylla* var. *japonica* 'Whitespire'), and gray birch (*B. pendula*). After 28 days without irrigation, Japanese birch maintained significantly higher stomatal conductance (g) and net photosynthesis (P<sub>n</sub>) than did any of the other species, despite having one of the lowest mid-day water potentials. Evaluation of tissue water relations, using pressure-volume methodology, showed no evidence of osmotic adjustment for any of these species in response to water stress. However, there was substantial variation among species in the water potential at the turgor loss point; varying from a high of -1.34 MPa for river birch to a low of -1.78 MPa for Japanese birch. Rates of P<sub>n</sub> and g under mild stress (mean predawn leaf water potential of -0.61 MPa) were negatively correlated with leaf osmotic potential at full turgor and the leaf water potential at the turgor loss point.

# ECTOMYCORRHIZAE AND RATE OF WATER DEFICIT DEVELOPMENT INFLUENCE PHOTOSYNTHESIS IN PINUS TAEDA L. SEEDLINGS

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*Pinus taeda* L. seedlings inoculated with the ectomycorrhizal fungus, *Pisolithus tinctorius*, were grown in a glasshouse for eight months, and then subjected to rapidly developing cyclic water deficits, or to a single slowly developing water deficit. Water deficits developed at a rate of 0.16 MPa per day (predawn total water potential) for five cyclic water deficits, and at 0.04 MPa per day for the slow water deficit. In unstressed seedlings, carbon exchange rates (CER) did not differ between noninoculated and inoculated seedlings. During slow water deficit development, CER steadily declined. During rapid water deficit development, CER remained unchanged, then declined rapidly when water potentials fell below -1.3 MPa. Inoculated seedlings had higher CER when water potential was lower than -1.5 MPa.

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EFFECT OF COPPER SULFATE FILTERS ON GROWTH OF  
BEDDING PLANTS

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Height control is a major concern when growing bedding plants. Growth regulating chemicals are often applied to regulate height of bedding plant species. However, reductions in plant height have been observed when plants were grown under light with a high ratio of red to far red light. Light passing through clear double walled, acrylic panels filled with copper sulfate solution has a high red to far red ratio. This work examined the effect of growing tomatoes, peppers, pansies, petunias, geraniums, and impatiens under panels filled with 4, 8, and 16 percent copper sulfate solution. Plants were grown for approximately 3 weeks in cell packs, then data were taken on plant height, number of leaves, leaf area, fresh and dry weight, and chlorophyll content. Significant reductions in height (40-66%) were achieved by growing bedding plants under any of the copper sulfate concentrations.

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EFFECTS OF SPECTRAL FILTERS ON GROWTH OF *DENDRANTHEMA GRANDIFLORA* (TZELEV.)

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'Spears' (nonpinched and pinched) and 'Yellow Mandalay' (pinched) chrysanthemums were grown in growth chambers equipped with clear, double-walled polycarbonate panels filled with liquids that served as spectral filters. A blue dye raised FR/R by filtering out a portion of red light. A solution of CuSO<sub>4</sub> lowered FR/R by absorbing a greater portion of far-red than red light. A red dye absorbed much of the blue/green portion of the light spectrum but did not change far-red to red (FR/R) light ratio. Two controls (H<sub>2</sub>O and air) were used. FR/R values were 1.01 for blue dye, 0.34 for CuSO<sub>4</sub>, and 0.86 for air, H<sub>2</sub>O, and red dye. FR and R were measured at 725-730 and 655-660nm, respectively.

All plants grown under CuSO<sub>4</sub> filters had reduced height, reduced internode length, and increased chlorophyll content compared to controls. Red dye filtered pinched plants had decreased chlorophyll compared to controls.

Pinched plants grown under CuSO<sub>4</sub> filters and long days developed fewer nodes than controls due to the formation of abnormal capitula. The controls and other treatments developed more nodes before producing similar capitula. Stem diameter and leaf area of controls did not differ from blue dye, red dye, or CuSO<sub>4</sub> filter treatments.

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INFLUENCE OF MODIFIED LIGHT QUALITY ON *DENDRANTHEMA GRANDIFLORA* TZVELEV. GROWTH

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The use of light quality as an alternate method for controlling ornamental plant growth was evaluated using copper sulfate solutions as optical filters. The light passed through CuSO<sub>4</sub> solutions had high red/far-red (R/FR) ratio. Plant height and average internode length were significantly reduced by high R/FR light. Plants grown under high R/FR light had smaller leaves and a lower total leaf area but had thicker leaves, as indicated by specific leaf weight, than the control plants. Fresh and dry weights of leaves, stems and roots were reduced by high R/FR light. Dry matter accumulation in leaves was increased by high R/FR light while it was reduced in stems. Exogenous gibberellic acid (GA) application partially overcame the height reduction under high R/FR light indicating that GA biosynthesis maybe affected by light treatment. Results suggests alteration of light quality could be used in controlling ornamental plant growth as an alternate method to conventional chemical growth regulator applications.

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COMPARISON OF GROWTH REGULATOR SPRAYS FOR POINSETTIA HEIGHT  
CONTROL

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Cuttings (3 per 1.5-liter pot) of 'Annette Hegg Lady' and 'V-14 Glory' poinsettias were directly rooted under mist and subsequently grown for treatment with various growth regulator sprays. Sprays of 40 ppm and 61 ppm paclobutrazol, 2,500 ppm daminozide plus 1,500 chlormequat, 20 ppm and 40 ppm ethephon, 150 ppm ancymidol, 5,000 ppm daminozide, 20 ppm and 40 ppm uniconazole, and 25 ppm and 50 ppm flurprimidol were applied to the plants with a low

pressure, high volume sprayer on October 23. Sprays of 40 ppm uniconazole caused the most height retardation with both cultivars, however 4000 ppm ethephon, 20 ppm uniconazole and 61 ppm paclobutrazol often gave comparable height retardation. Bract area of both cultivars was most severely retarded by 40 ppm uniconazole and 4,000 ppm ethephon.

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## EFFECT OF PREPLANT BULB SOAK WITH UNICONAZOLE ON GROWTH AND DEVELOPMENT OF EASTER LILY

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Plant growth and flower development of Easter lilies (*Lilium longiflorum*) were evaluated for 3 years (1988-90). Bulbs of cvs. Ace and Nellie White were soaked preplant in solutions of uniconazole at cones. of 0 to 5 ppm at durations of 1 to 5 minutes and compared to bulbs soaked in ancymidol at 5 to 40 ppm. Time of bulb soak had no effect on amount of solution absorbed and on growth and flower development. Plant height from bulbs soaked in water alone was variable among the 3 years, ranging from 56 to 70 cm for Nellie White and 55 to 89 cm for Ace. Ancymidol concs. of 5, 10, 20, and 40 ppm retarded plant height 10.8, 14.5, 33.8, and 46.2%, respectively. Uniconazole solutions at 0.625, 1.25, 2.5, 5, 10, and 20 ppm produced Nellie White plants 16.7, 70.4, 56.8, 46.9, 39.3, and 30.8% of the height of the water soaked bulbs, respectively. Response of Ace to similar uniconazole concentrations was slightly less. High uniconazole concentration (> 5 ppm) delayed flowering time and reduced the number of floral buds which developed. Variability among plants within uniconazole treatments was large and would not be acceptable commercially.

571

IRRADIANCE AND TEMPERATURE EFFECTS ON DEVELOPMENT OF *BEGONIA SEMPERFLORENS-CULTORUM*

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Effects of temperature (18-32°C), irradiance (0-4.3 mol day<sup>-1</sup>m<sup>-2</sup>), and pH (4.5-7.5) on germination of begonia were evaluated. Germination of 90-93% occurred at 18-24°C and 79-83% at greater than 24°C. There was no difference in germination between seeds receiving ambient irradiance conditions and seeds receiving 24hr supplemental irradiance (4.3 mol day<sup>-1</sup>m<sup>-2</sup>). Begonia did not germinate in the dark. On filter paper, no germination occurred at pH 4.5 or 5.0 while germination of 84 and 94% occurred within the pH range 5.5-7.5. In a peatlite medium, germination ≥ 80% occurred across all pH levels evaluated.

Photosynthetic photon flux (PPF), day temperature (DT), and night temperature (NT) effects on vegetative development (3 true leaves to first flower) were determined. Plant height increased <2 cm as PPF level increased from 4.4 mol day<sup>-1</sup>m<sup>-2</sup> to 12.15 mol day<sup>-1</sup>m<sup>-2</sup>. DT and NT influenced plant height, but as with PPF, the differences were only 1-2 cm. Neither average daily temperature (ADT) nor the difference between the DT and NT (DIF) affected plant height. Primary lateral shoot number increased as temperature and PPF increased.

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PHOTOPERIODIC CONTROL OF DEVELOPMENTAL GROWTH IN *BEGONIA* × *TUBERHYBRIDA*

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Plants of *Begonia* × *tuberhybrida* 'NonStop Orange', 'Clips Orange' and 'Musical Orange' were exposed to 1, 2, 3 or 4 weeks of short days initiated at 4 stages of plant development (immediately upon germination, 5 weeks after germination, 10 weeks after germination and 15 weeks after germination). Prior to and succeeding short days, plants were exposed to a day length of 16 hours at 100 μmol·m<sup>-2</sup>·s<sup>-1</sup>. Short days were 9 hours at an irradiance level of 180 μmol·m<sup>-2</sup>·s<sup>-1</sup> to give the same total daily irradiance (5.8 mol·m<sup>-2</sup>·day<sup>-1</sup>) as long day conditions. The temperature was maintained at 21° ± 4°C during the day and 18° ± 2°C during night. The observed growth and development responses were similar among the studied cultivars. During the period of 4 to 8 weeks after germination, the seedling height increased at an average rate of 0.7 mm day<sup>-1</sup> for plants grown under long days and 0.3 mm day<sup>-1</sup> for short day plants. The photoperiodic conditions did not affect the number of emerging leaves. The root development was more proliferate on plants allowed to develop under long days compared to plants exposed to short days during early development.

## 101 ORAL SESSION (Abstr. 573-580) CROSS-COMMODITY: HERBICIDES AND GROWTH REGULATORS

573

THE EFFECTS OF WEED INTERFERENCE: IN NEWLY PLANTED VINEYARDS  
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Initial weed competition in newly planted grapevines can delay vine development, resulting in reduced first harvest. The experiments were conducted over a three year period on three wine grape varieties: Chardonnay, Semillon, and Napa Gamay.

Dormant rooted plants were winter planted and subjected to soil applied preemergence herbicides. The experiment was conducted on a Greenfield sandy loam under sprinkler irrigation. Major weeds were little mallow (*Malva pariflora*), hairy nightshade (*Solanum sarachoides*), lambsquarters (*Chenopodium album*), and Russian thistle (*Salsola iberica*). Vine growth was evaluated on cane weights, cane diameter, and cane length. Weed interference over the three year period resulted in 50% reduction in vine growth the first year. Yield data obtained from the third year resulted in significant differences between the weed free vines compared to the non-weeded treatments.

574

RESPONSE OF COMMON BERMUDAGRASS TURF TO FERTILIZER AMENDMENTS AND IMAZAQUIN HERBICIDE  
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The herbicide imazaquin is used for purple nutsedge control on certain turfgrasses. Common bermudagrass exhibits stunting and slight discoloration effects after applications at the label rate. A field experiment was conducted to evaluate the effects of either N, Fe, or Mn applied either 2 days before or after applications of the imazaquin. Three applications were made 8-10 days apart in 1988. Initially, amendments applied prior to the herbicide reduced the discoloration. Fe was as effective as N in preventing discoloration, but not in correcting discoloration (after herbicide application). After the second and third applications, Fe was superior to N when used in the "preventative" mode. Mn showed no real effects. Two weeks after the third applications were made, the plots which received either none (checks) or any of the three amendments without the herbicide had better color than those which received the herbicide with or without the amendments. Iron chlorosis-type symptoms were a function of the amendment type-used, as N-enhanced chlorosis occurred on N checks and on herbicide plots receiving N, regardless of application order.

575

FIELD EVALUATIONS OF CRYOPROTECTANTS FOR PROTECTION OF TOMATO AND PEPPER TRANSPLANTS FROM FROST AND FREEZE

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The ability of two cryoprotectants to protect tomato and pepper transplants during frost and freeze conditions was evaluated in Clayton, NC. A commercially available cryoprotectant (50% propylene block copolymer of polyoxyethylene, 50% propylene glycol, tradename FrostFree) was evaluated during 4 spring and 3 fall seasons. An antitranspirant (96% di-1-p-Menthene, i.e. Pinolene, a terpenic polymer, 4% inert, tradename VaporGard) was evaluated for 2 spring and 1 fall season. Protection from these products was not observed under the field conditions experience? Yield differences were not observed between the treated and untreated plants. With several days of cool weather preconditioning, transplants survived air temperatures of -2.0 to -1.0 C with no damage. However, with no preconditioning, damage occurred at -1.0 C without the formation of frost. At -3.5 C all plants, both treated and untreated, died. Both crops were stunted and delayed by periods of cold temperatures even when no freezing temperatures were experienced.

576

DIKEGULAC-SODIUM SPRAYS ALLEVIATE CORRELATIVE INHIBITION IN ASPARAGUS CULTIVARS

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On Sept. 23, 1988, 12-month-old greenhouse-grown 'Mary Washington', 'Emerald', 'UC 157 F<sub>1</sub>' and 'UC 157 F<sub>2</sub>' asparagus seedlings were sprayed with dikegulac solutions ranging from 0 to 750 mg-l<sup>-1</sup> with 150 mg-l<sup>-1</sup> increments. The potted plants were then transferred to a lathhouse to simulate the weather conditions in the field. No significant shoot emergence occurred prior to killing frosts and low temperatures in December. The rise of the temperature in Jan. and Feb. 1989, promoted shoot emergence in all cultivars; but 'Mary Washington' did not respond to the treatments. At 600 mg-l<sup>-1</sup>, the chemical increased shoot emergence in 'Emerald', 'UC 157 F<sub>1</sub>' and 'UC 157 F<sub>2</sub>' by a respective cumulative average of 310, 161 and 305% over the control on 2 Feb. After intervening killing frosts and low temp, at the resumption of growth in late February 1989, 'UC 157 F<sub>1</sub>' and 'Mary Washington' were first to respond to the residual effects of the chemical, giving at 750 mg-l<sup>-1</sup> a respective cumulative increase of 65 and 77% over the control. Dikegulac did not affect the height and dry weight of 'Mary Washington' ferns. But it reduced the height of 'Emerald' without affecting its dry weight.

577

APPLICATION OF DORMANT OIL TO PEACH TREES MODIFIES INTERNAL BUD-TWIG ATMOSPHERE

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Treatments of dormant oil, at rates of 0, 3, 6, 9, or 12 % (v/v), were sprayed until drip on four year old 'Biscoe' peach trees on February 6, 1990. Another treatment was applied as a split application with 6% applied on the previous application date and a second application of 6% solution applied on February 12. The internal atmosphere of bud and twig was modified by the oil treatment. The internal concentration of CO<sub>2</sub> was elevated the morning following treatment and continued higher than the control for seven days. A second application of 6% oil resulted in additional elevation of internal CO<sub>2</sub>. External evolution of CO<sub>2</sub> of all oil treated twigs was 6 to 18% lower than the control 8 days after treatment. Bud phenology and bloom date of trees receiving higher rates of oil were slightly delayed.

578

PESTICIDE INFLUENCE ON NITROGEN FIXATION AND MODULATION BY SOYBEAN AND LIMA BEAN

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The influence of 12 pesticides on C<sub>2</sub>H<sub>4</sub> reduction and modulation of soybean (*Glycine max* L. Merr.) and lima bean (*Phaseolus lunatus* L.) was evaluated. All except diazinon were innocuous at 3× the label rate. Diazinon decreased C<sub>2</sub>H<sub>4</sub> reduction of soybean 2 days after application, but not after 7 days or at normal label rates. Nitrogen fixation of excised nodules imbibed with diazinon indicated that it may have directly affected nitrogenase function. Soybean nodule numbers were decreased by application of 3× rates of methomyl and trifluralin, but lima bean nodule numbers were decreased only by trifluralin. Trifluralin also depressed soybean but not lima bean modulation at label rates. Methomyl did not affect soybean modulation at label rate. Both chemicals were non-toxic to *Rhizobium* sp. in a disc inhibition study.

579

PENETRATION OF OCTYLPHENOXY SURFACTANTS THROUGH ISOLATED TOMATO FRUIT CUTICLES

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Despite the widespread use of surfactants to enhance the performance of foliar applied chemicals, the mechanisms for this enhancement are poorly understood. The penetration of surfactant *per se* through the cuticular membrane (CM) may play a pivotal role. Thus, we examined CM penetration by octylphenoxy surfactants (Triton X series) using a finite dose (Franz) diffusion cell. The effect of hydrophile length was studied using <sup>14</sup>C surfactant (15.9 mm in 20 mm citrate buffer: pH 3.2) with 3, 9.5, 12, 16, and 40 ethylene oxide units per molecule (EO). One 5-μl droplet of surfactant solution was

applied to the outer morphological surface of CM enzymatically isolated from mature tomato fruit. The inner CM surface remained in contact with stirred buffer at 25°C. The buffer was sampled periodically through a side portal over 648 h. Penetration curves (time vs. % penetrated) for all surfactants were characterized by three phases: lag, linear, and asymptotic. Lag: There was no effect of EO on the length of the lag phase (average 5 h) Linear: Steady state penetration (0.6 to 1.1% / h) was inversely related to log EO content. Asymptotic : About 70% of applied short EO (3 to 16) surfactants penetrated while 25% of the 40 EO penetrated in 648 h.

580

SPRAY DROPLET/CHEMICAL DEPOSIT INTERACTION WITH LEAF SURFACES  
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Most growth regulators and crop protection chemicals are delivered to the plant as aqueous sprays. Spray droplet:plant surface interaction is central to establishing spray and, hence, dose retention by the plant. Further, the nature of chemical deposition from spray droplets plays an important role in determining the efficiency of the active ingredient (a.i.). Using scanning electron microscopy and dispersive x-ray analysis, we investigated chemical deposit formation of selected growth regulators (e.g. ethephon, 2,4, 5-TP, TIBA) on leaf surfaces differing in wettability and surface fine-structure. The a.i. frequently deposited in the form of an annulus on droplet drying, and the degree of spreading was related to surface tension of the spray solution, and wettability, fine-structure and morphology of the leaf surface. Marked differences were observed in spreading following impaction on veins vs. interveinal areas of leaves of *Prunus* and *Pyrus* sp. The epidermis over veins was more readily wetted leading to rapid lateral diffusion along veins. Surfactants (e.g. Tween 20, Regulaid) altered the deposition pattern, expanding the annulus and increasing spreading on the leaf surface.

## 117 ORAL SESSION (Abstr. 581-588) FRUIT CROPS: POSTHARVEST PHYSIOLOGY II

581

HIGH CO<sub>2</sub> SLOW COOLING CA STORAGE FOR 'MCINTOSH' APPLES

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A high CO<sub>2</sub> slow cooling CA storage procedure was developed for 'McIntosh' apples (*Malus domestica* Borkh.). The apples were cooled from 18° to 3°C in 15 days in atmospheres containing a constant O<sub>2</sub> at 2.5% and decreasing CO<sub>2</sub> starting with 12% and ending at 3%. The results of several tests in a flow-through simulated CA storage system revealed that the new procedure was nearly as effective as rapid CA and was much more effective than traditional slow CA in preserving the firmness of 'McIntosh' apples for up to 4 months of storage. Maintaining a constant CO<sub>2</sub> either at 12% or 3% instead of gradually decreasing it from 12% to 3% during the slow cooling period resulted in more storage disorders or/and softer apples.

582

CHANGE IN SYNTHESIS OF NON-ETHYLENE VOLATILES FOLLOWING APPLE FRUIT STORAGE IN ATMOSPHERES INDUCING ANAEROBIC METABOLISM.

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Apple fruit storage life is prolonged by low-oxygen cold storage, however, ethanol accumulates when oxygen concentration is reduced below the Pasteur point. Upon return to aerobic conditions, dissipation of ethanol occurs due to physical (evaporation) and biochemical processes. Oxidation of ethanol by apple fruit occurs at a slow rate, but ethanol also serves as a substrate for fruit volatile

synthesis. This study was conducted to determine changes in concentrations of ethanol and other non-ethylene apple fruit volatiles following periods of anaerobiosis. 'Delicious' apples were obtained from a commercial warehouse and stored at 0.05% O<sub>2</sub>, 0.2% CO<sub>2</sub> and 1 C. One day following return to ambient oxygen conditions, several volatiles were identified from anaerobic fruit that were not produced by the control fruit. All were esters that contained an ethyl group as the alcohol-derived portion. These included ethyl acetate, ethyl butyrate, ethyl 2-methyl butyrate, ethyl hexanoate and ethyl octanoate. Several esters produced by the controls were not detectable from anaerobic fruit including butyl butyrate, butyl 2-methyl butyrate, propyl hexanoate and 3-methyl butyl hexanoate. After 7 days ripening at 20 C, the amount of ethanol and the additional ethyl- esters was reduced in anaerobic fruit. Synthesis of esters produced by control fruit but not by anaerobic fruit during the initial volatile sampling had resumed after 7 days.

583

INTERACTION BETWEEN OXYGEN LEVEL AND THE RIPENING OF 'GALA' APPLES

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In the past three years we have studied the effects of oxygen on the maturation and ripening of 'Gala' apples. Fruit-respiration, the onset of the climacteric rise in ethylene evolution and the rate of increase in ethylene production were measured. The effects of oxygen on softening and titrable acidity were also assessed. The delay in the onset of the climacteric rise in ethylene evolution shows enzymatic-type kinetics, with saturation levels of about 8-10% oxygen. Treatment with pure oxygen was highly detrimental; it induced visual symptoms of low-oxygen damage and high levels of ethanol. The slope of the rise in ethylene evolution is also a function of oxygen concentration, with an apparent Km for oxygen lower than that which delays the climacteric onset. The effect of oxygen on respiration is dependent on the physiological state of the fruit. In preclimacteric fruits, levels of oxygen between 2 and 8% eventually decrease respiration. Calculations of internal oxygen levels indicate that the diminution of respiration results from decreased metabolic activity in response to hypoxia.

584

CHILLING INITIATES ETHYLENE PRODUCTION IN GRANNY SMITH APPLES  
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The onset of the respiratory and ethylene climacterics in Granny Smith apples is usually protracted when the fruit are held continuously at 20°C. We have found that a period of at least 4 days at 0°C stimulates ethylene production when the fruit are returned to 20°C. Once initiated ethylene production proceeds at a high rate. Data will be presented showing the pattern of ethylene production following chilling by Granny Smith apples from two commercial districts in Australia. Our data suggests that a period of chilling stimulates ACC Synthase as in Winter Pears.

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THE EFFECTS OF PREHARVEST ENVIRONMENTAL FACTORS ON ENDOGENOUS ANTIOXIDANTS AND SCALD DEVELOPMENT IN APPLES

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Superficial scald development on apples is related to preharvest environmental conditions, perhaps through effects on endogenous antioxidant concentrations. In 1989 we examined effects of maturity, light, and preharvest temperatures (< 10°C) on endogenous antioxidant levels in the fruit at harvest and on scald development after long-term storage in 0°C air. Cortland apple trees were sprayed with 500 ppm ethephon 1 month before normal harvest to create maturity differences. Fruit on other Cortland trees were bagged 1 month prior to harvest to reduce light interception. Samples also were harvested from other Cortland trees after exposures to different numbers of hours < 10°C. Hours < 10°C before harvest were negatively correlated to scald development. Ethephon treatment decreased scald incidence, and bagging increased it. The total lipid-soluble antioxidant activity increased with increasing hours < 10°C and with ethephon treatment, while bagging of fruit slightly decreased this antioxidant activity. To better understand the relationships between preharvest factors and antioxidant levels, individual antioxidants, including ascorbic acid, α-tocopherol, anthocyanins and glutathione, are being analyzed.

## EFFECTS OF ROOTSTOCK ON 'DELICIOUS' APPLE FRUIT PROPERTIES

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The effects of rootstock on 'Delicious' apple maturity, quality, size, mineral composition, and storability were studied over a 4-year period. Removing the effects of crop load and crop load within year by analysis of covariance produced results suggesting that M.27 EMLA and Ott.3 advanced fruit maturity and that M.7 EMLA delayed fruit maturity. M.9, MAC 9, OAR 1, M.9 EMLA, and M.26 EMLA either were inconsistent in their effect on maturity or consistently resulted in an intermediate maturity. Size, after adjusting for the effects of crop load and crop load within year, was consistently high for fruit from trees on M.9 EMLA, and lowest for fruit from trees on OAR 1. After adjusting for fruit size, fruit from trees on MAC 9 generally had high Ca contents, and fruit from trees on OAR 1 had low Ca contents. The effect of rootstock on storability appeared to be secondary and related to maturity and Ca level.

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## SENSORY ATTRIBUTES OF APPLESAUCE PROCESSED FROM APPLES PRESSURE INFILTRATED WITH CALCIUM CHLORIDE PRIOR TO STORAGE

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'Golden Delicious' ('GD') and 'Red Rome' ('RR') apples were pressure infiltrated at harvest with 0, 1, 2, 3 or 4% and 0, 2, 4, 6 or 8% CaCl<sub>2</sub> solutions (w/v), respectively. Sauce was prepared after 0, 2, 4 and 6 months in 0°C storage. Sensory evaluation was conducted to determine the effects of CaCl<sub>2</sub> concentration on color, off-flavors, consistency, uniformity of particles, and overall acceptability of the sauce. Sauce from 'RR' was lighter while sauce from 'GD' was darker with increased CaCl<sub>2</sub>. Calcium chloride increased the consistency of 'RR' and 'GD' sauce but the highest concentrations decreased the consistency of 'GD' sauce. The uniformity of sauce particles from both cultivars decreased with increased CaCl<sub>2</sub>. The presence of off-flavors increased in 'GD' sauce with the highest concentrations but decreased in 'RR' sauce as CaCl<sub>2</sub> was increased. Overall acceptability of sauce made from 'RR' and 'GD' increased as CaCl<sub>2</sub> increased, however, acceptability of sauce made from 'GD' decreased at the highest concentrations of CaCl<sub>2</sub>.

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## THE EFFECTS OF FOLIARLY APPLIED CALCIUM ON FRUIT CALCIUM, FIRMNESS, SOLUBLE SOLIDS, STORABILITY AND ORGANOLEPTIC QUALITY OF 'CRESTHAVEN' PEACH

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Both CaCl<sub>2</sub> and Nutrical (a trihydroxyglutarate chelate) were foliarly applied at rates of 1.8 and 5.5 CaCl<sub>2</sub>/ha/season and 1.5 and 4.5 l/ha/season, respectively. Applications were made starting at shuck split and repeated at 2 week intervals until harvest. Neither calcium treatment had an effect on fruit size and size distribution. Fruit size was directly related to crop load. Calcium chloride application had the most pronounced effect on increasing the red over-color of 'Cresthaven' peaches with Nutrical intermediate compared to the control. The high rate of Nutrical increased flesh calcium levels at harvest by 75-100 PPM. Instron Texture Profile Analysis indicated that any calcium treatment significantly increased the hardness of the peach. Nutrical at 4.5 l/ha/season improved hardness 2-fold compared to the controls. The improved hardness was maintained throughout the 6 week storage period.

## 118 ORAL SESSION (Abstr. 589-596)

FRUIT CROPS:  
NUTRITION

589

## NITROGEN ALLOCATION AND ESTIMATION OF NITROGEN CONTENT AND REMOVAL IN LEAVES AND FRUIT OF NITROGEN-FERTILIZED AND NITROGEN-DEFICIENT WALNUT TREE CANOPIES

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Nitrogen (N) deficiency reduced biomass and altered N allocation within large walnut tree canopies (*Juglans regia* L. cv Serr). N-fertilized control trees contained 2.5 times more N in current year spurs, leaves and fruit than did those of N-deficient trees. The N content and biomass allocated to kernels was reduced in N-deficient canopies to a greater extent than was allocation to current year shoots and foliage. N removal in abscised leaves and fruit was 3 times greater in canopies of fertilized trees than in N-deficient trees.

A non-destructive method is described to calculate total spur, leaflet and fruit numbers. Calculations were based on ratios of fruit counts on selected scaffold limbs to total fruit number per tree. Dry weight and N content of representative spurs, leaflets and fruit permitted estimation of whole canopy biomass and N content in these organs. N contained in current year spurs and the N lost from the tree in fruit and leaf litter were calculated for both N-fertilized control and N-deficient trees.

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## EFFECT OF MID-SUMMER FOLIAR BORON SPRAYS ON QUALITY OF 'DELICIOUS' APPLE FRUIT

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Fruit growers and shippers have suggested that excessive rates of boron (B) in foliar nutrient sprays may reduce quality of stored apples. Foliar B sprays were applied by handgun in mid-July to bearing apple trees (*Malus domestica* Borkh. cv. Starking) at rates of 0, 11.3, 22.6 g B/tree. Fruits of uniform size (220 g) were analyzed for B content at harvest and for quality indices at harvest, after 10 days ripening postharvest, after 3 months refrigerated air storage, and after 8 days ripening poststorage. Whole fruit B concentration was directly proportional to B application rate. At all sampling times fruit firmness, soluble solids, titratable acidity, and internal and external color parameters were independent of whole fruit B concentration. Fruit disorders were unrelated to treatment except for internal breakdown after 8 months refrigerated air storage, which was positively related to whole fruit B concentration. Increases in fruit B were relatively greater in the core tissue, suggesting that some of the applied B entered the fruit through the tree vascular system.

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THE EFFECTS OF VINE SPACING, SHOOT DENSITY AND FOLIAR KNO<sub>3</sub> ON NUTRIENT CONTENT OF SEYVAL GRAPEVINES

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Factorial treatments of vine spacing, shoot density and foliar applications of KNO<sub>3</sub> were imposed on 9-year-old Seyval grapevines during 1989. Rows were spaced 3.05 m apart; vines within the row were spaced 1.2, 1.8 or 2.4 m apart and trained to a bilateral cordon. Shoots were thinned to 10, 20 or 30/m of canopy. A solution containing 6 kg of KNO<sub>3</sub>/379 liters of water was applied as a foliar spray at 2-week intervals between June 1 and August 1, 1989 (5 applications). Each shoot was thinned to one cluster prior to full bloom. Vines spaced at 1.2, 1.8 and 2.4 m produced an average of 4.2, 5.9 and 7.3 kg/vine, respectively (11.3, 10.6 and 9.8 MT/ha). Cluster weight averaged .22 kg; fruit maturity averaged 19.7°Brix for all treatments. Applications of KNO<sub>3</sub> increased foliar N, K, Fe, B, Cu and Na, but decreased P, Ca, Mg, Mn, and Zn. As vine spacing increased the concentration of foliar N, P, K decreased. As shoot density increased N, P, K, B, and Cu decreased, while Ca, Mg, Mn and Na increased. The experiment will be repeated in 1990.



## FOLIAR NUTRIENT UPTAKE IN CRANBERRY

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Foliar feeding of crop plants is an increasingly popular practice. The use of foliar nutrients relies on the ability of the plant to absorb nutrients through the leaves. Cranberries (*Vaccinium macrocarpon* Ait.) are known to have a waxy cuticle on the leaf surface which may impede nutrient uptake, leaving only the lower leaf surface for effective uptake. This study was undertaken to determine the extent of foliar nutrient uptake by cranberries using rubidium as a tracer. Rubidium was chosen for its similarity to potassium in plant uptake. In replicated plots, cranberries were sprayed with rubidium at the rate recommended for foliar potassium at three different growth stages and three different times of day. Washed and unwashed leaves were analyzed one day, one week, and one month after rubidium applications. Stem, soil, and root material was analyzed for rubidium at the one week and one month sample times. Results will be discussed with reference to uptake and movement of foliar applied nutrients in cranberries.

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## N RATE AND TIMING AFFECT ON CRANBERRY YIELD AND YIELD COMPONENTS

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Cranberries (*Vaccinium macrocarpon* Ait.) require low rates of N fertilizer compared to many horticultural and agronomic crops. Excess N promotes vegetative growth at the expense of yield. Growers desire information about N fertilization to achieve optimum yields without overgrowth. Little information has been published about N rate and timing influence on cranberries in south coastal Oregon. An N rate and timing field experiment with Crowley and Stevens cultivars was established to answer grower questions. N was applied at 0, 18, 36 and 54 kg/ha in various combinations at popcorn (white bud), hook, fruitset, early bud, and late bud. Yield, yield components, (fruit set, number of flowering and total uprights, berry size, flowers per upright and the proportion of uprights that flower), vegetative growth and anthocyanin content were measured. After 2 years of treatments, N rate or timing had little influence on yield or yield components in the previously heavily fertilized Crowley bed. In the previously lightly fertilized Stevens bed, N rate increased yield, vine growth, and the number of flowering uprights, N timing also influenced the number of flowering uprights. The total number of uprights was influenced by the interaction of N rate and timing.

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## FATE OF APPLIED NITROGEN FERTILIZER ON OREGON CRANBERRIES.

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Little work has been done to establish the rate and timing of nitrogen fertilizer applications to optimize return from fertilizer expenditures and minimize potential for ground and surface water pollution in Oregon cranberries (*Vaccinium macrocarpon* Ait.). Predicting cranberry N requirements is difficult because cranberries require little N and soil tests for N are not helpful for perennial crops, especially when grown in shallow sandy soils. We used <sup>15</sup>N-labeled ammonium sulfate to measure both plant uptake and movement of fertilizer N in a south coastal Oregon cranberry bed. A bed planted to the Stevens variety was fertilized with <sup>15</sup>N-labelled ammonium sulfate at two rates (18 kg/ha and 36 kg/ha) applied at five phenological stages: popcorn, hook, flowering, early bud, and late bud. Plant N uptake and translocation were measured throughout the growing season in uprights, flowers, berries, and roots. Initial results indicate that when N was applied at popcorn stage approximately 12% of the N was present in the above-ground vegetative biomass at harvest. Incorporation of fertilizer N into the duff and mineral soil was measured. An estimate of fertilizer N leaching was made by trapping inorganic N below the root zone using ion exchange resin bags.

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## LOWBUSH BLUEBERRY RESPONSE TO PHOSPHORUS FERTILIZATION. John M. Smagula\* and M. Susan Erich., Department of Plant, Soil, and Environmental Sciences, University of Maine, Orono, ME 04469

Nutrition Surveys of commercial blueberry fields in 1987 and 1988 indicated leaf phosphorus levels were below the standard (0.125%) in most fields. To determine if phosphorus was limiting, liquid phosphorus (23% phosphoric acid) was applied preemergence at 0, 22.4, 44.8, 67.2, or 88.6 kg/ha to 3 commercial blueberry fields identified in 1987 as very low (<.111%), 3 low (.111-.125%), and 3 adequate (>.125%) in leaf phosphorus. Phosphorus

concentration in leaf tissue sampled in July 1989 increased linearly with increasing rates of phosphorus. Phosphorus application raised leaf phosphorus levels more in fields which had levels below 0.125%. Fields with higher phosphorus levels were also higher in leaf nitrogen, potassium, and calcium.

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INFLUENCE OF SUPPLEMENTAL CA<sup>2+</sup> ON UPTAKE AND TRANSLOCATION OF <sup>22</sup>Na<sup>+</sup> IN RABBITEYE BLUEBERRY

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Blueberry reducers in Texas must often irrigate with sodic water. Excess Na<sup>+</sup> leads to reduced growth, necrosis, and plant mortality. Ca<sup>2+</sup> is known to ameliorate such detrimental effects in many crops, but little is known about the response of rabbiteye blueberry. To elucidate the influence of Ca<sup>2+</sup> on the uptake and translocation of Na<sup>+</sup>, plants were subjected to NaCl in hydroponics solutions (10, 25, 50 and 100 mM NaCl) and the uptake of Na<sup>+</sup> was traced over a 24h period using <sup>22</sup>Na<sup>+</sup>. Additionally, for each treatment, half the plants were supplied with 10 mM Ca<sup>2+</sup>. Plants were then transferred to identical, but unlabeled, solution, then harvested at intervals up to 28 days following cessation of labelling.

Preliminary results indicate that plants subjected to 25 mM Na<sup>+</sup> and 0 mM Ca<sup>2+</sup> showed less ability to exclude Na<sup>+</sup> from the roots, and accumulated more Na<sup>+</sup> in roots, stems, and leaves than did plants supplied with 25 mM Na<sup>+</sup> and 10 mM Ca<sup>2+</sup>. Leaf tissue accumulated more Na<sup>+</sup> per gram fresh weight than did any other part of the plant, regardless of Ca<sup>2+</sup> treatment.

Results from the remaining treatments, root <sup>22</sup>Na<sup>+</sup> efflux data, and total tissue Na<sup>+</sup> and Ca<sup>2+</sup> concentrations will also be reported.

## 119 ORAL SESSION (Abstr. 598-604)

### VEGETABLE CROPS: STRESS PHYSIOLOGY

598

## EFFECT OF MECHANICAL STRESS ON CONDITIONING AND YIELD OF FOUR JAPANESE CULTIVARS OF CUCUMBER

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Cucumber (*Cucumis sativus* L.) seedlings were brushed with a suspended bar for 1.5 min twice daily for 12 days (ST) prior to planting. One group of plants was brushed for an additional 10 days (LT) after planting. ST reduced stem length 12 to 28% and shoot dry weight 6 to 24% with 'Kurume-ochiai-H' least responsive. ST reduced the numbers of female flowers on lateral shoots of 'Ritsurin' and 'Chikanari-suhyoh' while LT affected 'Nanshin' and 'Chikanari-suhyoh'. Brushing did not affect the total number of fruits or mean fruit size or weight of any cultivar, but both ST and LT decreased the total yield of 'Ritsurin' grown in a plastic house. Brushing provides good growth control of containerized cucumber transplants with some responses differing among the cultivars. [Project funded by JSPS and Monbusho.]

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## SEASON OF SEED DEVELOPMENT AFFECTS GERMINATION OF LETTUCE SEED WITH HIGH TEMPERATURE

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Lettuce (*Lactuca sativa* L.) seed germination is inhibited at temperature higher than 25-30°C. The extent of this inhibition varies between seed lots. Our objective was to determine how the season during which seed develops affects the ability of seeds to germinate and establish a stand at high temperatures. Lettuce seed, 'Empire', was produced during 2 summers and 2 winters (1988 and 1989) in Yuma, AZ. These seeds were germinated at 20, 25, 30 or 35°C in petri dishes or in growth pouches to determine percent

germination or root lengths, respectively. Electrical conductivity of seed leachates was measured. Field emergence of seeds was tested with early fall plantings in Yuma, AZ. Percent seed germination was greater and root lengths were longer for the seeds produced in summer than in winter. Conductivity will be correlated with relative tolerance to high temperatures of the different seed lots. In the field, percent emergence of seed lots from summer and winter averaged 60% and 38%, respectively.

600

#### HEAT TOLERANCE OF SELECTED TOMATO CULTIVARS AND GERMPLASM LINES

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Selected breeding lines and cultivars of tomatoes (*Lycopersicon esculentum* Mill.) were evaluated for heat tolerance in the greenhouse (39°C day and 28°C night) and field using flowering, fruit-set, yield, fruit quality, and seed production as criteria. Under high temperature, heat tolerant lines performed better than the other two groups in all evaluation criteria except for seed production. The opposite was found under normal field conditions where heat sensitive commercial cultivars outyielded the heat tolerant lines and cultivars. Production of viable seeds under high temperature was severely reduced regardless of the heat tolerance level exhibited by the line or cultivar. Some of the heat tolerant lines could provide valuable sources of plant material for physiological studies to establish the molecular basis of heat tolerance and also could provide excellent germplasm sources for breeding heat tolerant tomato cultivars.

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#### TOMATO FRUIT QUALITY AND ION STATUS: THE EFFECTS OF SALINITY, PHYTOPHTHORA ROOT ROT AND GENOTYPE

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Tomato fruit quality can be improved by the use of moderately saline irrigation water. However, decreased fruit yields may occur if the saline treatment is initiated early in plant development or the salt concentration is high. Another concern with the use of saline irrigation water is increased plant susceptibility to disease. Two processing tomato cultivars were grown under low salt (ECa=1.1 ds/m), medium salt (ECa=2.8 ds/m) and high salt (ECa=4.6 ds/m) regimes, and in the presence and absence of *Phytophthora parasitica*, the causal agent of Phytophthora root rot. Salinity increased Phytophthora root rot severity in UC82B, the susceptible cultivar, but had a limited effect on CX8303, a cultivar known to have a measure of resistance to Phytophthora root rot. Fruit acidity and percent total soluble solids were enhanced in both cultivars by increasing salinity. Infection by *P. parasitica* increased acidity and soluble solids in UC82B fruit grown under high salt. Sodium and chloride concentrations in tomato fruit increased in a manner proportionate to the salt treatment applied; however, in the absence of disease, fruit Na and Cl levels were markedly lower compared to other tissues in the plant. The presence of salt-enhanced Phytophthora root rot in UC82B increased fruit Na concentration by almost 100%. Fruit Ca and K levels, in contrast, declined moderately with increasing salinity and were not affected by disease.

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#### SALINITY STRESS RESPONSES OF MINIATURE DWARF TOMATO IN A WHOLE PLANT MICROCULTURE EVALUATION SYSTEM

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A whole plant microculture (WPMC) screening system facilitated rapid, quantitative appraisal of salt stress effects on 'Micro-Tom' miniature dwarf tomato. Axillary bud explants were micropropagated on a hormone-free control medium (conductivity = 3.3 dS m<sup>-1</sup>), gradually introduced to treatments with increasing NaCl or Na<sub>2</sub>SO<sub>4</sub> concentrations via biweekly subculture to fresh media (7.6, 12.8, or 18 dS m<sup>-1</sup>), and monitored over a subsequent 5 week culture period. Non-intrusive video image analysis techniques were adapted to quantify morphometric (shoot growth rate, area, and length; root length and area) and photometric (ruler and tissue quality) plant responses. Shoot growth was only slightly inhibited at 7.6 and 12.8 dS m<sup>-1</sup>, but was severely stunted and distorted on high salt (18 dS m<sup>-1</sup>) media. Root growth inhibition (significantly shorter and thinner primary roots) was first evident at 12.8 dS m<sup>-1</sup> after 3 weeks of treatment. At 18 dS m<sup>-1</sup>, conspicuous retardation of root growth relative to controls could be gauged after only one week. Shoot tip chlorosis was observed in the lowest salt-supplemented treatment after three to four weeks of culture, but overall shoot yellowing at the two highest conductivities was marked after only a few days. Chlorosis symptoms were not uniform within treatments. Cell osmotic concentration showed a linear increase with increasing medium salinity. The WPMC system expedited time course observations of stress symptom development, paralleled stress response trends observed in solution culture tests, and provided an excellent vehicle to investigate plant adaptation to saline conditions.

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#### SALT TOLERANCE IN TEN CULTIVARS OF EGGPLANT

(*Solanum melongena* L.)

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Eggplant is an important vegetable crop in Kuwait. Eggplant is considered to have moderately sensitive salt-tolerance, though no quantitative information is available on its salt sensitivity. Selecting salt-tolerant genotypes in eggplant is an ongoing project at Kuwait Institute for Scientific Research. Towards the goal of selecting salt-tolerant genotypes in eggplant a completely randomized experiment using 10 cultivars, replicated 3 times were tested against 2 levels of high salinity stress (EC MS.cm<sup>-1</sup> at 25°C, 15.0 and 18.0) along with the control (EC MS.cm<sup>-1</sup> at 25°C, 3.0). The experiment was conducted on 15 days old seedlings inside a greenhouse. Data on shoot length and visual observations on leaf necrosis, leaf collapse and root color was also recorded. There was a clear degree of variability as well as significant differences in growth and final survival, between cultivars at 2 levels of salinity stress. Those genotypes that showed significant higher growth rates and survival without any signs on leaf necrosis and root collapse formed the basis salt-tolerant genotypes.

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#### EFFECT OF SALT SHOCK ON PHOTOMIXOTROPHIC SUSPENSION CULTURES OF SOYBEAN

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When plants are subjected to stress conditions, they are believed to be developing defensive mechanisms. Those mechanisms could be studied by analysing and comparing the proteins from stressed and nonstressed plant materials. Photomixotrophically grown soybean suspension cultures were shocked with 150 mM, 200 mM, and 250 mM salt concentrations for 1 hr. and 3 hrs. The cells were then given 2, or 4 hr. recovery period. After treatment, proteins were quantified, using Bradford Assay, and then separated on SDS PAGE gels. In Coomassie stained gels, there were different banding patterns in shock treated samples, compared to the control. But there were no differences identified between different shocking times or recovery period treatments. The results from Silver staining and growth studies will be presented.

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## 120 ORAL SESSION (Abstr. 605-612)

### CROSS-COMMODITY TISSUE CULTURE IV

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605

#### ESTABLISHING CULTURES FROM MATURE PECAN EMBRYO EXPLANTS ON MEDIA WITH LOW WATER AVAILABILITY

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Endophytic fungi associated with mature pecan nuts (cultivars 'Smart', 'Desirable' and 'Owens') prevented successful, contaminant-free, in vitro culture of embryo explants, even after rigorous surface disinfection of the nuts and careful aseptic shelling. Disinfection with sodium hypochlorite after removing the shells was also unsuccessful, because even dilute concentrations which were ineffective against the fungal contaminants destroyed embryo viability. An alternative disinfection technique is required to establish in vitro cultures from mature pecan explants. Explanting media with low water availability were developed to capitalize on the relatively stringent requirement of most fungal contaminants for free water. The explanting media were supplemented with 0.9-1.5% agar. Other media components were selectively included or omitted to test their influence on water activity and fungal growth. After four weeks of culture, the incidence of contamination was reduced to 30% or less on modified explanting media, compared to 100% loss to contamination on control medium (0.5% agar). The brief initial culture period effectively eliminated fungal contamination from cultures by plasmolyzing fungal hyphae or denaturing fungal protein, without effecting pecan embryo viability. Cultures remained contaminant-free after transfer to control medium. Axillary and adventitious bud development from disinfested embryo axes was subsequently induced in a medium with 18 µM BAP and 5 µM IBA, and regeneration from cotyledon explants was accomplished in a medium with 50 µM NAA. This disinfection technique allows mature pecan embryo explants to be used in biotechnology.

# THE EFFECT OF PULSED EXCIMER LASER RADIATION ON CONTROL OF IN VITRO CULTURE CONTAMINATION AND THE GROWTH OF HEDERA CANARIENSIS.

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This study was initiated to investigate the effect of pulsed XeCL excimer laser radiation (308 nm) at 25 and 50 pulses per second at radiation levels of 0, 100 mJ, 200 mJ, and 300 mJ on microorganism contamination of in vitro cultures of *Hedera canariensis*. Explants were cultured on Murashige and Skoog (MS) medium supplemented with 8 mg/BA and 0.2 mg/NAA. The medium was adjusted to pH 5.7. The cultures were maintained for 16-hours photoperiods at 25.5°C. One day following transfer the explants were treated with pulsed excimer laser radiation. The percentage of contamination was reduced by laser radiation treatments. The effect of 50 pulses of radiation was found to increase the petiole length, leaf blade width, and leaf number of explants.

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# SHOOT TIP CULTURE OF MUSCADINE GRAPE TO ELIMINATE PIERCE'S DISEASE BACTERIUM

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Screening of muscadine grape (*Vitis rotundifolia*) plants in vineyards has revealed that many plants carry *Xylella fastidiosa*; under suitable conditions, this bacterium causes Pierce's disease which can result in considerable loss. To determine whether propagation of muscadine through shoot tips would eliminate *X. fastidiosa*, plants were injected with this bacterium. After demonstrating infection, shoot tips were collected and cultured, according to the technique of Barlass and Skene (1978). Plants which were regenerated were found to be free of the bacterium. To determine whether this shoot-tip culture technique would be effective for propagation of a diverse group of muscadines, 19 cultivars were tested. Three of the cultivars failed to produce any plants, and several others reproduced at a low rate of efficiency. In an attempt to improve the rate of regeneration, several modifications to the technique were tested. For most cultivars, better initiation occurred on liquid medium, more shoots were produced with BA than with 2iP, and the addition of adenine sulfate and sodium phosphate improved the regeneration frequency.

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# MICROPROPAGATION OF *THEOBROMA CACAO*, A RECALCITRANT SPECIES, WITH HIGH CO<sub>2</sub>

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Cacao (*Theobroma cacao*) has long been considered a recalcitrant species in regard to micropropagation. Although axillary shoots from cotyledonary nodes will proliferate and grow *in vitro* provided either cotyledons or roots are attached, excised shoots fail to grow in spite of conventional medium and hormonal modifications. Charcoal supplemented medium and rapid medium change are only marginally effective in inducing shoot elongation. The recalcitrance of cacao appear to be due to the presence of gums which are produced from stem tissues in response to wounding. However, growth of axillary cotyledonary shoots as well as mature shoots was obtained under conditions of high CO<sub>2</sub> (20,000 ppm) and high light (quantum flux of 200  $\mu\text{mol m}^{-2}\text{s}^{-1}$ ) with or without sugar. Under these conditions leaves develop and shoots elongate which can be subdivided and subcultured. Shoots root under these conditions *in vitro*. We hypothesize that growth of cacao shoots in response to high CO<sub>2</sub> is due to translocation of metabolites from photosynthesizing leaves and stems.

609

# ENHANCED REGENERATION OF SHOOTS FROM PEACH CELLS INFECTED WITH A SHOOTY MUTANT STRAIN OF AGROBACTERIUM.

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Immature 'Redhaven' peach (*Prunus persica* L. Batsch) embryos were infected with *Agrobacterium tumefaciens* strain tms328: :Tn5 carrying the functional cytokinin gene. Shoots were regenerated from callus grown on MS medium without added phytohormones and subsequently rooted on half-

strength MS medium with 2.8  $\mu\text{M}$  4-naphthaleneacetic acid. These plants exhibited an increased frequency of branching *in vitro*. Low levels of cytokinin gene transcripts were detected in these cells by Northern analysis, and using an ELISA assay, the cytokinins zeatin and zeatinriboside were determined to be on the average 30-fold higher. From these results, the expression of the cytokinin gene appears to promote growth of cells in the absence of phytohormones thus serving as a marker for transformation and a promoter of morphogenesis without a 2,4-dichlorophenoxyacetic acid inductive step.

610

# A TWO-STAGE MICROPROPAGATION SYSTEM FOR CRANBERRIES

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In an effort to accelerate breeding programs and to study somaclonal variation, a micropropagation system was devised for cranberries (*Vaccinium macrocarpon*). Using a factorial design, explants taken from greenhouse grown plants were placed on Anderson's medium containing different concentrations of 2iP, GA<sub>3</sub>, and IBA, with 4 cultivars tested over 3 subcultures. In other experiments, explant source, macro and micro salt formulations, and rooting treatments, were studied. Optimal multiplication and shoot quality occurred when single node explants taken from greenhouse grown plants were placed on Anderson's media containing 150  $\mu\text{M}$  2iP, 1.0  $\mu\text{M}$  IBA and no GA<sub>3</sub>. Histological examinations indicate that initial response is axillary bud proliferation but upon subculture adventitious shoot formation may be possible. Proliferated shoots could be rooted *ex vitro* in plug trays under plastic tents and without hormone treatments. Optimal rooting occurred under high light conditions in a 1:1 (v:v) peat:sand mix. Plants were easily transplanted into the field in spring and will be evaluated by comparison to conventionally propagated material.

611

# EFFECT OF CO<sub>2</sub> ENRICHMENT AND LIGHTING ON STAGE IV ROOTING AND ACCLIMATION OF MICROPROPAGATED KALMIA.

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The objective of this study was to determine the feasibility of CO<sub>2</sub> enrichment and optimal radiation level for accelerating the rooting and growth of micropropagated *Kalmia latifolia* cuttings during the Stage IV acclimation period. Inch long microcuttings of the *Kalmia* cultivars 'Elf' and 'Carousel' shipped from a commercial micropropagation laboratory, were stuck in flats of peat, and place in a fogging chamber constructed to allow for the simultaneous experimental variation of CO<sub>2</sub> level and either radiation level or photoperiod. Treatments consisted of a complete factorial arrangement of 2 levels of CO<sub>2</sub> (ambient and 1200 ppm) and 3 levels of radiation (30, 98, and 158  $\mu\text{moles/m}^2\text{/sec}$ ). The experiment was repeated 6 times. For 'Carousel' CO<sub>2</sub> enrichment stimulated both shoot and root growth and either the high or medium light level was optimal depending on the experiment. CO<sub>2</sub> enrichment also stimulated growth of 'Elf' but results were less consistent from experiment to experiment. Similar experiments are in progress with *Amelanchier* and *Lilac* microcuttings.

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# SHOOT POSITION, IBA AND AGROBACTERIUM RHIZOGENES INFLUENCE PROPAGATION OF HAZELNUT, *CORYLUS AVELLANA*

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Propagation of *Corylus avellana* stem cuttings may be limited by either root initiation or bud abscission. We divided juvenile shoots of 3 varieties growing in layering beds in mid-July into 4 or 5 3-node cuttings with leaves at the upper two nodes, except that terminal cuttings had one expanded leaf. Cuttings were treated with 5 mM IBA in 50% EtOH, a mixture of *A. rhizogenes* strains A7 + 22 or left untreated. IBA and bacteria stimulated rooting of cuttings from all shoot positions. Rooting of the terminal cuttings (<50%) was less than that of the sub-terminal cuttings (>80%). Bud retention was <50% on terminal cuttings, nearly 100% on sub-terminal cuttings. Using juvenile stock plants of various varieties, sub-terminal cuttings treated with *Agrobacterium* or 5 mM IBA may yield 70-90% cuttings with both roots and buds. Agravitropic roots, characteristic of genetic transformation, were observed on *Agrobacterium*-treated cuttings. Dot blots probed for T<sub>1</sub>-DNA were negative, however.

# 121 ORAL SESSION (Abstr. 613-620)

## CROSS-COMMODITY GROWTH CHAMBERS AND CONTROLLED ENVIRONMENTS

613

### CHARACTERIZATION OF AIR MOVEMENT PATTERNS AND VELOCITY EFFECTS ON PLANT DEVELOPMENT IN A GROWTH CHAMBER

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Chrysanthemum, wheat, and soybean were grown in a growth chamber to study the effects of airflow direction, velocity, and turbulence on vegetative growth. These three plant species were chosen to examine how plants with different leaf architectures and morphology are influenced by varying air velocity and pattern. A hot wire anemometer accurate to  $\pm 0.025 \text{ m s}^{-1}$  and capable of responding to 50 kHz turbulent velocity fluctuations was used to characterize the environment in a growth chamber under three different experimental conditions:  $< 0.50 \text{ m s}^{-1}$  horizontal velocity,  $> 1.00 \text{ m s}^{-1}$  horizontal velocity, and  $< 0.50 \text{ m s}^{-1}$  vertical velocity. Plants were grown under the three different treatments for five weeks with plant height, width, stem diameter, and node number, and fresh and dry weights of leaves, stem, and roots determined at three intervals throughout each experiment. Tire variation in plant development resulting from the different treatments has practical implications for using ventilation to aid in controlling plant growth and development.

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### NUTRIENT ACCUMULATION IN POTATO PLANTS GROWN IN NFT AT VARIED FLOW RATES AND SOLUTION CONCENTRATIONS

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A modified nutrient film technique (NFT) with a shallow granite medium was developed to control the flow rate and concentration of nutrients to which potato plants were subjected. Flow rates were 2, 4, and 8 ml per minute with balanced nutrient concentrations at 25, 50, and 100% (0.6 to  $2.4 \text{ dS m}^{-1}$  conductivity) of modified Hoagland's solution that was not recycled. Potato growth was greatest and about equal at 4 ml of 50% solution and at 8 ml of 25% solution. In shoots, accumulation of P, Fe, and Mn increased with both increasing concentrations and increasing flow rates. Zn accumulation decreased with increasing concentrations, and Ca, Mg, and Cu accumulation decreased with increasing flow rates. Accumulation of K, S, and B differed little with either concentrations or flow rates. In tubers, the differences resulting from variations in concentrations and flow rates were less than in shoots but accumulation patterns were similar except Ca and Mg accumulation did not decrease with increasing flow rates and K accumulation increased with both increases in concentration and increases in flow rate.

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### GA EXCHANGE RATES BY A STAND OF SOYBEANS GROWN IN A TIGHTLY SEALED CHAMBER

R.M. Wheeler\*, K.A. Corey, J.C. Sager, C. L. Mackowiak, and W.M. Knott. NASA Biomedical Operations and Research (JCS, WMK) and The Bionetics Corp. (RMW, CLM) Kennedy Space Center, FL 32899 and Dept. of Plant and Soil Science, University of Massachusetts, Amherst, MA 01003.

Soybean plants [*Glycine max* (L.) Merr. cv. McCall] were grown from seed to harvest (90 days) in NASA's Biomass Production Chamber. The chamber provides approximately  $20 \text{ m}^2$  of growing area with an atmospheric volume of  $113 \text{ m}^3$ . Photosynthesis and respiration rates of the stand were tracked by monitoring  $\text{CO}_2$  increase during the 12-h dark period and the subsequent drawdown to controlled set point ( $1000 \text{ ppm}$ ) when the lamps were turned on each day. Stand photosynthesis [under  $875 \mu\text{mol m}^{-2} \text{ s}^{-1}$  photosynthetic photon flux (PPF)] peaked at  $35 \mu\text{mol m}^{-2} \text{ s}^{-1}$  at 30 to 35 days after planting (DAP) and averaged  $22 \mu\text{mol m}^{-2} \text{ s}^{-1}$  throughout the life cycle. Dark period respiration peaked near  $8 \mu\text{mol m}^{-2} \text{ s}^{-1}$  at 30 to 35 DAP and averaged nearly  $5 \mu\text{mol m}^{-2} \text{ s}^{-1}$  throughout the life cycle. Prior to full canopy closure near 30 DAP, the light compensation point (LCP) for stand photosynthesis was less than  $100 \mu\text{mol m}^{-2} \text{ s}^{-1}$  PPF; by 54 DAP the LCP had increased to  $175 \mu\text{mol m}^{-2} \text{ s}^{-1}$ . Stand transpiration rates peaked at  $8.2 \text{ L m}^{-2} \text{ day}^{-1}$  at 40 to 45 DAP and averaged  $4.3 \text{ L m}^{-2} \text{ day}^{-1}$  throughout growth.

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### CARBON DIOXIDE EXCHANGE OF A WHEAT STAND GROWN IN NASA'S BIOMASS PRODUCTION CHAMBER

K.A. Corey\*, R.M. Wheeler, J.C. Sager, and R.P. Prince., Dept. of Plant & Soil Sciences, Univ. of Massachusetts, Amherst MA 01003, The Bionetics Corp., Kennedy Space Center, FL 32899, and NASA Biomedical Operations and Res., Kennedy Space Center, FL 32899.

A wheat (*Triticum aestivum* cv. Yecora Rojo) stand was grown using nutrient film culture in the closed conditions of NASA's Biomass Production Chamber. Rates of photosynthesis and respiration of the entire stand (about  $20 \text{ m}^2$ ) were determined daily using a regime of 20 hr light/4 hr dark,  $20 \text{ C}$  light/ $16 \text{ C}$  dark an average PPF of  $600 \mu\text{mol m}^{-2} \text{ s}^{-1}$  from HPS lamps, and a  $\text{CO}_2$  cone of  $1000 \text{ ppm}$ . Fractional interception of PPF by the stand reached a maximum of 0.96 at 24 days from planting. Rates of photosynthesis were constant throughout the photoperiod as determined by short term drawdowns of  $\text{CO}_2$  throughout the photoperiod. Drawdown rates of  $\text{CO}_2$  were correlated with rates determined by logging of mass flow of  $\text{CO}_2$  injected during chamber closure. Photosynthetic drawdowns of  $\text{CO}_2$  indicated that photosynthesis was not saturated at  $1000 \text{ ppm}$   $\text{CO}_2$  and that the  $\text{CO}_2$  compensation point was about  $50 \text{ ppm}$ . Whole stand light compensation points were 200 to  $250 \mu\text{mol m}^{-2} \text{ s}^{-1}$  between days 13 and 70 and then increased rapidly during senescence.

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### COWPEA HARVEST SCENARIOS AND EDIBLE BIOMASS PRODUCTION UNDER CONTROLLED ENVIRONMENTS

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CowPea (*Vigna unguiculata* (L.) Walp.) is a candidate species for inclusion in a space-deployed Controlled Ecological Life Support System (CELSS) because it contributes to a balanced diet with its moderate protein content, high complex carbohydrate content, and low fat content, and because leaves and unripe pods as well as dry seeds are edible. Four harvest scenarios were compared in the experimental line IT84S-2246 under controlled conditions with and without  $\text{CO}_2$  enrichment. Plants kept vegetative by removal of flowers and periodically stripped of fully expanded leaves yielded as much as either mixed-harvest scenario in which leaves were stripped at either 1- or 2-week intervals until pods started forming. The 2-week harvest scenario outyielded the 1-week scenario by 15 to 25%. The seed-only control produced the same amount of seeds as the 2-week leaf harvest scenario, but had lower total edible biomass because leaves were not harvested. Under  $1000 \text{ ppm}$   $\text{CO}_2$ , all treatments yielded from 30 to 70% more edible biomass than under non- $\text{CO}_2$ -enriched conditions. Research sponsored by NASA Cooperative Agreement NCC 2-100.

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### PERFORMANCE OF AN INTEGRATED AQUACULTURE-OLERICULTURE SYSTEM AS INFLUENCED BY COMPONENT RATIO

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Fish and vegetable production were linked in a recirculating water system. Hybrid tilapia were grown in tanks and fed a commercial feed. Tomato or cucumber were grown in sand biofilters associated with each tank. Four tank to biofilter volume ratios, ranging from 1:0.67 to 1:2.25, were studied by varying the biofilter size. Plant populations were directly proportional to biofilter volume and surface irrigated 8 times daily with aquacultural 'waste' water. Biofilter drainage returned to the fish tanks by gravity. Each system received identical nutrient inputs and plants received equal water. Biological filtration, aeration, and mineral assimilation by plants maintained water quality under rapid fish growth rates. Dissolved oxygen levels, make-up water, fish biomass increase and growth rates increased with biofilter volume. Total fruit yield increased but yield per plant decreased with increasing biofilter volume. Caloric content of the increase in fish biomass per liter of total water decreased while that of tomato increased with increasing biofilter volume. Calories in the combined yields per liter of water used did not differ by treatment. Total protein production per liter of water used decreased with increasing biofilter volume. Both caloric value and protein production in the combined outputs increased with biofilter volume irrespective of water consumption. Annualized economic value from the combined fish and 'Laura' tomato production per composite unit area ranged from \$98 to \$124  $\text{m}^2$  with decreasing tank to biofilter ratio.

# A MODEL FOR PLANT GROWTH IN CONTROLLED ENVIRONMENTS

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A simple plant growth model has been developed based on the analysis of growth curves of lettuce and spinach in numerous controlled environment experiments. The model incorporates elements for genetic potential, plant spacing, photosynthetic photon flux, photoperiod, environment, and morphology. Predicted parameters are relative growth rate, mean plant weight, and plant growth efficiency. Prediction may be on an hourly or daily basis. Examples drawn from data on various species and cultivars will be presented.

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# GROWTH, DEVELOPMENT AND NITROGEN METABOLISM OF HYDROPONIC LETTUCE GROWN UNDER HPS SUPPLEMENTAL LIGHTING

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Two cultivars (Karlo and Rosanna) of greenhouse lettuce were grown under different photosynthetic photon fluxes (PPF) and photoperiods provided by 400-W high-pressure sodium lamps. Natural light was compared to supplemental lighting treatments providing either 50 or 100  $\mu\text{mol m}^{-2}\text{s}^{-1}$  for photoperiods of 16, 20 or 24 h. Lettuce plants were grown in hydroponic gulleys using a standard nutrient solution. Plant fresh weights were measured every week for the duration of each culture grown between August 1989 and June 1990. The incidence of tipburn and the overall quality of the shoots were determined at the end of each crop. Leaf nitrate contents and nitrate reductase activity were measured for various lighting treatments. The highest fresh weight was obtained for the highest PPF and the longest photoperiod. However, these treatments were associated with a higher incidence of tipburn. Supplemental lighting reduced the leaf nitrate contents and affected the nitrate reductase activity.

## 132 ORAL SESSION (Abstr. 621-628) FRUIT CROPS: CULTURE AND MANAGEMENT III

621

# INSULATING CONES PROVIDE MORE FREEZE PROTECTION TO YOUNG CITRUS TREES THAN TRADITIONAL WRAPS

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Wraps of fiberglass or other insulating material have frequently been used in Florida for cold protection of young citrus tree trunks. Traditional wraps were compared to a foil-covered plastic bubble material formed into cones. The base of the cone on the ground trapped soil heat and the apex was secured around the trunk at a height of 40 cm. Cones with base diameters of 15, 30, 45 and 60 cm were compared to a cylindrical wrap of the same material and other traditional wraps. A major freeze in Dec. 1989 killed unprotected control trees to the rootstock. Cones provided better freeze protection than other wraps. Temperatures inside the cones were generally warmer as cone diameter increased. By trapping soil heat, cones of this material can provide better freeze protection of young trees when irrigation or other heat sources are not available.

622

# CITRUS ROOTSTOCK SHOOTS ENHANCE SCION GROWTH AFTER BUD FORCING

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Carrizo citrange [*Citrus sinensis* (L.) Osb.  $\times$  *Poncirus trifoliata* (L.) Raf.] seedlings were budded with 'Hamlin' orange [*Citrus sinensis* (L.) Osb.] and subjected to 3 bud forcing treatments: (1) topping [T] by

removing the seedling above the bud union; (2) lopping [L] by cutting half way through the seedling above the bud union and breaking the rootstock over; or, (3) bending [B] the seedling top over and tying it to the base of the plant. As scion buds emerged and grew, plants were sacrificed for dry weight measurements; also, the portion of the rootstock seedling above the bud union was exposed to  $^{14}\text{CO}_2$  at 3 stages of scion development. Plants with seedling tops attached (B,L) gained more dry weight and fibrous roots than T seedlings. Scion elongation was greater for B plants than for T plants. Plants usually flushed twice regardless of bud forcing treatment. No treatment differences were noted for time of flushing or scion bud emergence. Labeled photosynthate from attached rootstock leaves was translocated to scions during both flushes suggesting that recently fixed C enhanced scion growth for B and L plants.

623

# MICROSPRAYER VS. EMITTERS FOR IRRIGATING PEACH TREES WHEN USING A COMPUTER MODEL TO PREDICT APPLICATION RATES

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A computer model was used to predict irrigation rates and numbers of emitters or microsprayers required to trickle irrigate Redskin/Nemaguard peach trees. Irrigation rates were 0, 50%, and 100% of the predicted requirement based on a crop coefficient of 50, 80, 100, 80, and 50 percent of pan evaporation for the tree's canopy area for May, June, July, August and Sept. respectively. Full irrigation (100% of predicted) was applied through 6, 8L/hr emitters or one 48L/hr microsprayer. Half the predicted rate was applied through 6, 4L/hr emitters or 1 24L/hr microsprayer. Control trees received no supplemental irrigation. Microsprayers height was adjusted to wet a surface area comparable to the 6 emitters. There was no significant difference in fruit size or yield based on emitter vs microsprayers, but fruit size and total yield was increased in direct proportion to irrigation rate. There was no treatment effect on tree pruning weights. Moisture measurements indicated that trees de-watered the soil efficiently enough that water never moved below the 30 cm level in spite of the fact that up to 260 liters per tree per day were applied in mid-summer.

624

# RELATIONSHIP OF ROOTSTOCK SEEDLING CHARACTERISTICS TO FIELD VIGOR OF 'REDGLOBE' PEACH

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Eight rootstock cultivars of peach (*Prunus persica*) were grown for 3 months in a greenhouse and evaluated for vigor by measuring root hydraulic conductivity and recording stem caliper, shoot and root dry weights, and root lengths. These data were compared with tree diameter data from 3rd leaf 'Redglobe' orchard trees budded on the same rootstock cultivars. The objective was to determine if rootstock seedling growth could be used as a predictor of scion vigor in the field. Correlations between orchard tree diameters and the stem calipers ( $r = 0.87$ ), whole plant dry weights ( $r = 0.91$ ), and root dry weights ( $r = 0.89$ ) of greenhouse rootstock were statistically significant ( $P < 0.05$ ), but not significant was the correlation between root length ( $r = 0.76$ ) and tree diameter. Root hydraulic conductivity as measured with a pressure-induced water flux system at 0.4 MPa of pressure and calculated on both a root length and a root dry weight basis was inversely correlated with both the greenhouse and field data. This suggested that root hydraulic conductivity was a function of a pressure-mediated mechanism that was independent of root membrane permeability and xylem conductance.

625

# EFFECTS OF GROUND COVER MANAGEMENT SYSTEMS AND WATER DEFICIT STRESS ON QUALITY OF APPLE

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A field study was initiated in 1981 in western North Carolina to determine the influence of eight groundcover management systems on quality of 'Redchief Red Delicious' apple (*Malus domestica*) grafted onto rootstock of M VIIA. Management systems included: bare soil, Secale cereale mulch, minimal cultivation, *Festuca arundinacea*, *Dactylis glomerata*, *Poa pratensis*, *Muhlenbergia schreberi* and *Rubus* sp. Thus far, fruit quality data indicate that fruits produced in plots of cool-season grasses are smaller and less mature than those produced in vegetation-free plots or plots of warm-season grasses. A negative correlation was noted between high fruit quality and water deficit stress as measured by water potential and stomatal conductance.

INFLUENCE OF ORCHARD-FLOOR VEGETATION MANAGEMENT ON APPLE TREE GROWTH, NUTRIENT UPTAKE AND LEAF TRANSPIRATION RATES  
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Eight vegetation management systems (VMS) were evaluated over four years in a newly planted apple site. VMS treatments included pre- and post-emergence herbicide strips, a close-mowed sodgrass, a growth-suppressed (maleic-hydrazide) sodgrass, a crownvetch "living mulch," clean cultivation, and straw mulch. Soil moisture supply was highest under the straw mulch and lowest under crownvetch, and varied inversely with groundcover biomass. Leaf N was deficient in trees in both sodgrass VMS, and increased by the legume "living mulch" only after four years. Leaf Cu was lowest, and appeared to limit tree growth in VMS with prolonged soil moisture deficits. No significant differences were observed in leaf transpiration over a broad range (10 to 700 kPa) of soil matric tension. Cumulative trunk cross-sectional area was greatest in straw-mulched trees and least in sodgrass and crownvetch VMS. The optimal soil matric tension for nutrient uptake and tree growth appeared to be 175 to 200 kPa in this orchard. Increasing the width of glyphosate herbicide strips from 1.5 to 2.5 m in tree rows did not improve tree growth, nutritional status or fruit yield.

627  
EFFECT OF ROOT PRUNING AND CHEMICAL THINNING ON GROWTH AND FRUITING OF 'McINTOSH' APPLE TREES.

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Mature 'McIntosh'/MM.111 apple (*Malus domestica*, Borkh.) trees were treated to evaluate the response of root pruned trees to chemical thinning and to determine if reducing the crop load increased fruit size on root pruned trees. The trees were root pruned at full bloom in 1988 and 1989, by cutting on both sides of the row 1m from the trunk and 30cm deep. Water, 600mg/liter carbaryl, 5mg/liter naphthaleneacetic acid (NAA), or NAA plus carbaryl were applied when fruit diameter was approximately 10mm. Trunk cross-sectional area (TCSA) was increased by thinning treatments in 1988, but root pruning had no effect. In 1989, root pruning reduced TCSA increment by 35%. Shoot length was reduced by root pruning both years. All treatments reduced percent fruit set in 1989, however root pruned trees and trees treated with NAA had the highest fruit numbers at harvest. Preharvest fruit drop was reduced by root pruning in both 1988 and 1989. Root pruning had no influence on the response of apple trees to chemical thinning. Removing a portion of the crop with chemical thinners was partially successful in counteracting the reduction in fruit size caused by root pruning.

628  
GROWTH OF NONPAREIL ALMOND TREES AFTER 20 C STORAGE UNDER VARYING CO<sub>2</sub> AND C<sub>2</sub>H<sub>4</sub> CONCENTRATIONS

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Nursery grown and budded one year old .8 cm 'Nonpareil' almond trees were placed bareroot in sealed containers at 2°C and subjected to concentrations of 0, 1, 3, 5% CO<sub>2</sub>, 0, 0.5, 1, 2 µl<sup>-1</sup> C<sub>2</sub>H<sub>4</sub>, or combinations of both gases. All trials were conducted under 100% R. H. and constant air flow. Trees were removed after 10 or 20 weeks and then grown in 19 l. containers for approximately 12 weeks before grading.

Growth was the same for all concentrations of CO<sub>2</sub> after 10 weeks but caused a 20 and 32% decrease in shoot growth at 3 and 5% concentrations after 20 weeks. C<sub>2</sub>H<sub>4</sub> caused 34, 34 and 89% decrease after 10 weeks and 78, 83 and 100% decrease of shoot growth after 20 weeks. Root growth was also seriously decreased.

C<sub>2</sub>H<sub>4</sub> caused no growth decrease after 10 weeks when 3 or 5% CO<sub>2</sub> was present. After 20 weeks CO<sub>2</sub> only partially offset the detrimental effect of C<sub>2</sub>H<sub>4</sub>.

## 133 ORAL SESSION (Abstr. 629-636) CROSS-COMMODITY GENETICS II

629

RELATIONSHIP BETWEEN MALATE DEHYDROGENASE GENOTYPE AND PLANT VIGOR IN PEACH

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The relationship between malate dehydrogenase (MDH) genotype and plant vigor in peach [*Prunus persica* (L.) Batsch] was examined in two F<sub>2</sub> populations (selfed 'Belle of Georgia' and 'Cresthaven') segregating at the Mdh1 locus. Total numbers of progeny examined were 1610 and 998 in the 'Belle of Georgia' and 'Cresthaven' populations, respectively. In both populations, plant vigor (as defined by total height and trunk caliper after 1 year of growth) was significantly less in homozygous F/F (Mdh1-1/Mdh1-1) individuals. Homozygous S/S (Mdh1-2/Mdh1-2) individuals showed the greatest vigor, and were significantly different in vigor from homozygous F/F (Mdh1-1/Mdh1-1) individuals in both populations and from heterozygous F/S (Mdh1-1/Mdh1-2) individuals in the 'Belle of Georgia' population. A significant deviation from the expected 1 F/F:2 F/S:1 S/S ratio was observed in the 'Belle of Georgia' population, suggesting moderate lethality of homozygous F/F genotypes.

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DIVERSITY, INHERITANCE, AND LINKAGE RELATIONSHIPS OF ALLOZYME CODING LOCI IN CUCUMBER (*Cucumis sativus* L.).  
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The available U. S. *Cucumis sativus* germplasm collection (754 Plant Introductions) was electrophoretically screened for genetic diversity using 39 enzymes representing a total of 57 loci. Polymorphisms were observed at 18 loci which included g2dh, gpi1, gpi2, gr1, gr2, idh, mdh1, mdh2, mdh3, mpi2, pep-la2, pep-pap2, per4, pgd1, pgd2, pgm1, pgm3, and skdh. Appropriate crosses were set up to verify the inheritance of and test linkages among these loci. Four allozyme linkage groups have currently been identified. Representative linkages and their genetic distances include: gpi1 - mdh3 (20); pgm1 - pgd1 (25); and g2dh - pgd2 (19). Additionally, crosses were made to marker stocks to test for linkages between some allozyme loci and loci coding for resistance to downy mildew and anthracnose, long hypocotyl, divided leaf, short petiole, glabrous, compact plant, determinate, little leaf, and bitter free (bi).

631

ISOZYME VARIATION IN SEXUALLY AND ASEXUALLY REPRODUCED GARLIC  
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Despite its long history of obligate vegetative propagation, garlic (*Allium sativum* L.) exhibits a surprisingly large amount of variation between clones, as evidenced by both morphological and isozyme markers. As reported previously, several garlic clones which produce viable seed have been identified in the Wisconsin collection, and a possible correlation between clone fertility, morphology, and isozyme banding patterns was examined. The potential use of isozymes to analyze sexually-derived hybrid garlic lines, haploids, and interspecific hybridizations was also investigated.

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ISOZYME VARIATION IN PACIFIC ISLAND CULTIVARS OF BREADFRUIT  
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150 accessions of breadfruit [*Artocarpus altilis* (Parkinson) Fosberg and *A. mariannensis* Trècul] and interspecific hybrids from 18 Pacific island groups were analyzed for isozyme variation. Six enzyme systems (ACO, ADH, IDH, MDH, ME, PGM) produced well-resolved bands. Each accession was scored for presence or absence of bands for each enzyme system. Breadfruit is clonally propagated and numerous diploid and triploid cultivars are grown in the Pacific islands. Diploid cultivars of *A. altilis* from Melanesia and western Polynesia showed the highest variation. Few diploid

cultivars were found in eastern Polynesia. Seedless, triploid cultivars showed identical banding patterns for all enzyme systems. The narrow genetic variation in triploid cultivars indicates that they are the result of repeated vegetative propagation of a naturally occurring triploid. In contrast, these cultivars exhibit great morphological variation due to somatic mutation, maintained through human selection. A. *mariannensis* and hybrid cultivars showed greater variation and were identifiable by unique banding patterns for ADH and MDH.

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#### ISOZYME CHARACTERIZATION OF CARIBBEAN FORBIDDEN FRUIT (CITRUS SP.) CLONES AND SEEDLINGS

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A diverse population of grapefruit-like Citrus growing in Saint Lucia (West Indies), called forbidden fruit, was examined as a potential germplasm source for Citrus genetic improvement. Four clones from this population were studied by leaf isozyme analysis, and a distinct resemblance between forbidden fruit and grapefruit (*C. × paradisi* Macfady.) was observed at several loci, including identical banding patterns for peroxidase, phosphoglucose mutase, phosphohexose isomerase, and shikimic acid dehydrogenase. These results support morphological and historical indications of a close taxonomic relationship between modern grapefruit cultivars and Caribbean forbidden fruit. Comparison of isozyme allele segregation among seedlings of several forbidden fruit clones and grapefruit cultivars demonstrated a much higher degree of zygotic embryony in the former. Morphological diversity and zygotic embryony in the Caribbean forbidden fruit population may make it a useful genetic resource for breeding grapefruit and other Citrus species.

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#### A GENETIC MAP OF CITRUS BASED ON ISOZYMES AND RFLPS.

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We report a preliminary genetic map of citrus based on segregation of 8 isozyme and at least 33 RFLP loci. The segregating population consisted of 60 plants from a cross of two citrus rootstock, 'Sacaton' citrumelo × 'Troyer' citrange. This cross represents an intergeneric F2 since 'Sacaton' is *Citrus paradisi* (grapefruit) × *Poncirus trifoliata* (trifoliate orange) and 'Troyer' is *C. sinensis* (sweet orange) × *P. trifoliata*. RFLPs were identified using anonymous probes from both cDNA and genomic DNA libraries of citrus. About 20% of the loci deviated significantly from Mendelian segregation. Two-point linkage analysis identified 8 linkage groups in which pairs of loci were within 30 centimorgans. This suggests that we have markers on most of the 9 chromosomes of Citrus. A map based on multipoint linkage estimates will be reported. Evidence for structural rearrangements between *Citrus* and *Poncirus* and extension of the map to additional marker and disease resistance loci will be discussed.

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#### MOLECULAR CHARACTERIZATION AND LINKAGE MAPPING OF THE CITRUS GENOME USING ISOZYME AND RFLP MARKERS

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Citrus genetic studies and cultivar improvement have been difficult with conventional techniques. Alternative approaches are needed to enhance efficiency of such studies. Our objectives were to characterize the Citrus genome and to initiate development of a linkage map using RFLP and isozyme analysis. Methods of Citrus DNA extraction were developed to allow the isolation of chromosomal DNA of acceptable quality for recombinant DNA manipulations. A PstI Citrus genomic library was constructed to create DNA clones for the RFLP survey. A rapid, reliable procedure was developed to facilitate screening of the library for useful clones. The methods used and strategy followed minimized contamination with organelle DNA, increased the frequency of single copy clones, and allowed rapid screening of the newly-constructed library. Linkage relationships of 49 markers, including 36 RFLP and 6 isozyme loci, were analyzed and a map comprised of 8 linkage groups was constructed. Insertions or deletions were responsible for at least 30% of the RFLPs identified. A hypothesis of transposon activity in Citrus was proposed based on our observations.

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#### LINKAGE OF RESTRICTION FRAGMENT LENGTH POLYMORPHISMS AND ISOZYMES IN A BACKCROSS OF CITRUS AND PONCIRUS

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Genetic linkage analysis was performed on an interspecific backcross of citrus [*Citrus grandis* (L.) Osbeck cv. Thong Dee X (Thong Dee X *Poncirus trifoliata* (L.) Raf. cv. Pomeroy)], using restriction fragment length polymorphism (RFLP) and isozyme analysis. Sixty-five progeny were analyzed for a total of 57 segregating markers including 9 isozymes and 48 RFLPs. Significant ( $p = 0.05$ ) deviation from an expected 1:1 segregation ratio was observed for 21 (37%) of the 57 loci, but this did not exclude their use in the mapping study. Linkage analysis revealed that 50 loci mapped to 12 linkage groups while 7 loci segregated independently from all other markers. The total map distance included in the 12 linkage groups was 472 cM with the mean distance between markers being 12.8 cM. This does not represent a saturation of the genome with markers; however, this work demonstrates the potential for mapping traits of economic importance in citrus.

### 134 ORAL SESSION (Abstr. 637-644) CROSS-COMMODITY TISSUE CULTURE V/ MICROPROPAGATION

637

#### CELL GROWTH OF EUCALYPTUS TETRAICORNIS CULTURE

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A suspension culture of *Eucalyptus tetraicornis* was initiated from callus and grown for 7 months under indirect light in a Murashige and Skoog (1962) basal medium containing 3% glucose and 1 mg/l 2,4-D. Glucose was used, instead of sucrose, as it reduced production of phenolic-like compounds. The inoculum size for maximum cell yield was determined. Cells (0.1, 0.2, 0.5, 1.0, 2.5 and 5.0 g fresh weight) were cultured in basal medium for 14 days. Maximum fresh weight (mean 11.8 g) was attained from samples inoculated with at least 1.0 g of cells. Largest dry weight (mean 608 mg) occurred following inoculation with at least 0.5 g fresh weight of cells. Inoculation with 0.5 g of cells resulted in the most rapid fresh weight doubling time (3.4 days).

After 17 months of culture, cells were grown in basal medium or in basal medium supplemented with 1 mg/l kinetin, under continuous, direct light. Growth, based on fresh and dry weight increases, was measured over the 2-week subculture period. Growth of cells was similar in both media. The cells' chlorophyll content remained low. Fresh weight doubling time averaged 3.8 days.

638

#### DEVELOPMENTAL AND REGULATORY MECHANISMS INVOLVED IN PECAN SOMATIC EMBRYO MATURATION

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Although somatic embryogenesis in vitro has been carried out successfully in a number of plants, a limiting factor in many somatic embryogenic systems is that plantlet regeneration is not obtainable or restricted to low frequencies. We have developed a repetitive, high frequency somatic embryogenic system in pecan (*Carya illinoensis*) and have identified effective treatments for improved somatic embryo conversion. A 6 to 10 week cold treatment followed by a 5 day desiccation, promoted enhanced root germination and extension, and epicotyl elongation. Light and transmission electron microscopic evaluations of somatic embryo cotyledon development will be presented and related to conversion enhancing treatments and their possible roles in embryo maturation.



# ANATOMICAL DEVELOPMENT OF ROOTS INDUCED BY *AGROBACTERIUM RHIZOGENES* ON APPLE SHOOTS GROWN IN VITRO

Juvenal Luza and Ellen G. Sutter\*, Dept. of Pomology, Univ. of California, Davis, CA 95616

Development of roots on M.26 apple shoots grown in vitro induced by *A. rhizogenes* was compared with that of roots induced by NAA. Shoots were inoculated with 4-day colonies of *A. rhizogenes* strain A4 and were sampled at 1, 2, 4, 8 weeks after inoculation. Roots formed on approximately 30% of inoculated shoots. Roots induced by *A. rhizogenes* typically were agravitropic and branching. The outer layer of cells on these roots, especially on older roots, often resembled callus and sloughed off easily when the plants were transferred. The internal structure of the roots did not differ between the two treatments. Roots induced by NAA always arose endogenously and clear connections to the vascular system of the shoots were apparent. Many roots induced by *A. rhizogenes* appeared to develop exogenously, arising from anomalous cellular proliferation in the cortex of the apple stems or in callus at the base of the stem. These roots also showed vascular connections to the shoot.

# REGENERATION OF PLANTS FROM STORED WITLOOF CHICORY FOR SELECTION OF DESIRABLE STORAGE TRAITS

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A micropropagation procedure was developed to regenerate plants via tissue culture from explants of harvested and stored French endive (*Cichorium intybus* L. Witloof). The procedure permits the rescue of French endive germplasm that shows resistance to postharvest physiological disorders and diseases. The procedure was used successfully to regenerate plants which showed resistance to different undesirable marketable traits. Under a long day photoperiod, a high percentage of the explants produced flowers in vitro. Thidiazuron was used successfully to regenerate plants from small leaf explants.

# IN VITRO REGENERATION FROM CALLUS OF ROSMARINUS OFFICINALIS

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Regeneration from callus of rosemary has not been reported. Leaf segment, meristem-tip and shoot-tip explants of *Rosmarinus officinalis* were cultured on a Murashige and Skoog (MS) medium supplemented with five concentrations of the cytokinin thidiazuron (TDZ) alone or in combination with 3-indoleacetic acid (IAA). Callus was formed on the base and leaves of the shoot-tips after 6 weeks when cultured under cool white fluorescent light ( $26 \mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ ) on MS containing 0.5, 1.0, 1.5 or 2.0 mg/l TDZ. Calli were transferred to fresh MS medium supplemented with 0.2, 0.4, 0.6, 0.8 or 1.0 mg/l TDZ or 2.0, 4.0, 6.0 or 8.0 mg/l benzyladenine (BA) where shoot formation occurred. Essentiality of IAA was not clear from these experiments and further research is underway to refine regeneration protocol

# SOMATIC HYBRIDIZATION BETWEEN CITRUS RETICULATA AND CITROPSIS GABUNENSIS THROUGH ELECTROFUSION

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Protoplasts were isolated from embryogenic calli of *Citrus reticulata* cv. Ponkan and *Citropsis gabunensis*, and fused in electric fields. The maximal fusion efficiency was obtained by application of AC at 75 V/cm (1.0 MHz) and DC square-wave pulse at 1.125 KV/cm for 40 usec. Fusion-treated protoplasts were cultured on MT medium without phytohormone, solidified with 0.6% agar. Colonies from the protoplasts were proliferated on MT medium with zeatin 1 mg/l and 0.9% agar. Selection of somatic hybrid callus was based on chromosome count and isoenzyme analysis. The somatic hybrids were tetraploid ( $2n=36$ ). *C. reticulata* and *C. gabunensis* were both homozygous at Got-1 locus, but distinguishable easily because band of the latter migrated faster than that of the former. In zymogram of somatic hybrid, both parent bands were retained and a new hybrid band was also evident between them. Embryos from somatic hybrid callus regenerated intact plant. The hybrid plants showed intermediate morphological characteristics of the parents.

# APPLICATION OF CALLUS CULTURE FOR THE STUDY OF BLACKSPOT DISEASE RESISTANCE IN ROSES

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The objective of this study was to determine whether tissue culture can be used for studying the blackspot resistance found in some roses. Callus was initiated from leaves, petioles, and stems of resistant and susceptible genotypes. Good callus formation for susceptible roses (hybrid teas) was obtained on a medium containing MS basal salts, vitamins, sucrose, and 8 g/L agar supplemented with 2 mg/L 2,4-D, 1 mg/L NAA, and 0.2 mg/L BA. Callus formation for resistant roses (species roses) was best when the concentrate ions of growth regulators in the medium were halved. Browning in species rose cultures, was decreased with the addition of 0.05 g/L ascorbic acid to the medium followed by incubation in the dark. The subculture calli were inoculated with the fungal conidia and were analyzed for proteins by SDS-PAGE. These protein profiles were compared to those of whole leaf samples. The results are discussed in terms of similarities and differences in the biochemical responses of callus cultures versus whole leaves to the blackspot infection.

# PROTOPLAST ISOLATION AND CULTURE OF SOME *IPOMOEA* SPECIES IN THE SECTION *BATATAS*.

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Sweet potato (*Ipomoea batatas* L. Lam) ranks second in world wide root and tuber production. Loss of genetic resources in the primary centers of origin have been occurring for a number of years. Utilization of the genetic diversity of wild types and related species can expand breeding potential and efficiency. Two species, *Ipomoea trifida* and *Ipomoea triloba*, have been identified as possible progenitor species or sweet potato. Plant improvement at the cellular level using protoplasts is a novel alternative to conventional breeding practices. Protoplast plating efficiency appears to be genotype dependent. Roots have been regenerated from *Ipomoea trifida* protoplasm calli on Murashige and Skoog's medium containing zeatin or kinetin.

## 135 ORAL SESSION (Abstr. 645-650) CROSS-COMMODITY SEED PHYSIOLOGY II

# PRIMING PETUNIA

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NaCl, KNO<sub>3</sub> (0.3, 0.4, 0.5M), KH<sub>2</sub>PO<sub>4</sub> (0.4, 0.5, 0.6M), and PEG 8000 (320 to 370 g/L with the increment of 10g/L) were used for priming *Petunia* 'Ultra White' seeds for three to six days. Seeds were germinated in a growth chamber at 25C. Germination was recorded for seven days and the number of acceptable seedlings (seedlings with open cotyledon and normal root) was counted on the day seven. KH<sub>2</sub>PO<sub>4</sub> at 0.6M was the best salt treatment. Rate of germination was improved by salt priming but the number of acceptable seedlings was lower than the control. Addition of GA (5 ppm) to the salt treatment was not effective. More abnormal seedlings were observed when seeds were primed in aerated salt solutions than when primed in petri dishes. Aerated PEG at 325 g/L for three days and 365 g/L for six days gave the best results. Priming in PEG improved percent of germination, rate of germination, and number of acceptable seedling as compared to control. Primed seeds lost some of the advantages of priming during 24hr air drying (22C), however quality was maintained when dried at 10C. Drying primed seed in 80% R.H. was not effective.

# NUTRIPRIMING: A METHOD TO IMPROVE GERMINATION PERFORMANCE OF OLD SPINACH SEEDS

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One-year old 'Coho' spinach seeds (*Spinacea oleracea* L.) were primed, air-dried, and germinated for 12 days to determine the effects of multi nutrient liquid chelate compound (Crop-Up) and its single nutrient chelate components on the germination performance of old seeds. Treatments consisted of Crop-Up, Ca, Mg, Mn, Fe, Zn, Cu, and B chelate solutions at concentrations of 5, 0.25, 0.11, 0.28, 0.25, 0.34, 0.10, and 0.05%, respectively. Distilled water was used for the check. Crop-Up-, Fe-, Zn-, and Cu-priming significantly increased both seedling fresh and dry weights, and improved seed germination by 23 to 32% over the check treatment. Al 1 nutrient treatments, except Cu, had a delaying effect on time of emergence. Fe-, Zn-, and Cu-priming treatments increased germination performance index by 21, 11, and 9%, respectively.

# RELATIONSHIP BETWEEN THE SEED COAT AND EMBRYO IN REGULATING THE EFFECT OF HEAT AND SALT STRESS ON LETTUCE SEED GERMINATION

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Poor germination of lettuce seeds exposed to heat and salinity is attributed to a reduction in the capacity for embryo expansion. Ethylene and kinetin are proposed to overcome these stresses by increasing the expansion force of the embryo which ruptures the seed coat barrier to growth. To better understand the physiological mechanism regulating thermodormancy in the embryo, germination was determined for intact and decoated seeds from thermosensitive and thermotolerant varieties subjected to a critical range of temperature and salt (NaCl) stress. Although more tolerant of stress, the response of decoated seeds to ACC and kinetin was similar to the response of intact seeds. No interaction between ACC and kinetin was detected in decoated seed except under the most severe stress and in the thermosensitive variety. Heat and salt tolerance appear to be governed by the same physiological mechanism. We propose that the seed coat plays no qualitative role in the expression of lettuce seed thermodormancy. The response occurs exclusively in the embryo and may result from an inability to generate sufficient turgor pressure at supraoptimal temperatures for cell expansion.

# GERMINATION OF VERBENA SEED IN RESPONSE TO PLANT GROWTH REGULATORS

Gamil A. Kabbabe\* and William J. Carpenter, Department of Environmental Horticulture, IFAS, University of Florida, Gainesville, FL 32611

Verbena seed when harvested, has a natural dormancy that gradually dissipates during a 5 to 8 month period of dry storage. In this study, the gradual loss of the dormancy causing factor was correlated with germination percentage. Acetone treatment of verbena seeds was found to cause a slight, but non-significant, reduction in total germination. However, the infusion of gibberellic acid ( $GA_3$ ) and kinetin (KIN) with the acetone at various concentrations improved germination. The traditional method of seed osmoconditioning using Polyethylene Glycol (PEG 8000) at -1.0 MPa caused a non-significant reduction in percent germination, similar to that with acetone. When growth regulators were mixed with the osmoconditioning solution, at the concentrations used with acetone, a definite and significant improvement in terms of rate and percent of germination was observed.

# ISOLATION OF VEGETABLE SEEDS BY SEMI-PERMEABLE MEMBRANE DURING MATRICONDITIONING

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Recently we have shown that the performance of vegetable seeds can be enhanced by matricconditioning in the presence of fixed amounts of chemically inert carriers, such as Micro-Cel<sup>TM</sup>E and Zonolite<sup>TM</sup> Vermiculite, and water (Khan et al. National Symp. Stand Estab. Hort. Crops, p.19, 1990). This procedure, however, does not allow separation of seeds from the carrier during seed conditioning. This problem has been overcome by enclosing the seed in a semi-permeable membrane and placing the seed-membrane system in contact with the carrier and water (or test solution). By this means, the equilibrium moisture content, needed for seed conditioning is attained readily. This

procedure allows conditioning of large amounts of seeds and eliminates the contamination of seeds from the carrier. The application of this procedure in seed enhancement within the seed industry will be discussed.

# LOW-OXYGEN TREATMENT OF PREGERMINATED IMPATIENS SEEDS TEMPORARILY SUPPRESSES RADICLE ELONGATION

Gary F. Polking\*, Richard J. Gladon, and David S. Koranski, Department of Horticulture, Iowa State University, Ames, IA 50011

Generation of pregerminated seeds at a central facility and subsequent mechanical sowing at a remote facility require that radicle elongation during shipment be minimized. Low-oxygen treatments were applied to pregerminated 'Super Elfin Salmon Blush' impatiens seeds to suppress radicle growth during a subsequent one-day simulated shipping period in air. In the first experiment,  $O_2$  concentrations of 0, 3, 7, 10, 13, and 20% were applied for 24 and 48hr. The 0%  $O_2$ /24-hr and the 0%  $O_2$ /48-hr treatments held the radicle length close to the desired length of 1.0mm, but both of these treatments decreased 7-day hypocotyl length and percentage normal seedlings, when they were compared with the control treatment (untreated pregerminated seeds). In the second experiment,  $O_2$  concentrations of 0, 1, 2, 3, 7, and 20% were applied for 24 and 48hr. Five treatments (0, 1, and 2%  $O_2$ /24-hr and 0 and 1%  $O_2$ /48-hr) held the radicle to a length <1.0mm. Of these five treatments, only the 2%  $O_2$ /24-hr treatment resulted in recovery parameters (7-day hypocotyl length and percentage normal seedlings) that compared with those of the control treatment.

## 136 ORAL SESSION (Abstr. 651-657) CROSS-COMMODITY COMPUTERS/EXTENSION

# REVISING THE SUPERVISORS INTERIOR PLANTSCAPE COURSE

Allen C. Botacchi\*, University of Connecticut Cooperative Extension System, Hamden, Connecticut 06514.

Prior to the fall of 1989, no Commercial Supervisory Pesticide Applicator Certification for the Interior Plantscape category existed in the State of Connecticut. The Cooperative Extension Educator for Commercial Horticulture and the Connecticut Department of Environmental Protection cooperated to establish the requirements for an Interior Plantscape Pest Control category.

The Extension Curriculum was revised to prepare individuals to take the Connecticut DEP examination. This course was taught during the summer of 1990.

Students were made more aware of the proper site and/or plant selection relationships. Emphasis was placed on careful and detailed inspection of newly purchased plant material. Additional cultural information was presented to reduce and/or eliminate the use of pesticides.

Course content and student survey results from this curriculum will be presented.

# ON FARM TRIALS WORK

David S. Nuland\* and Jim Schild, University of Nebraska, 4502 Ave I, Scottsbluff, NE 69361

We have looked at varieties and rates of added nitrogen in 56 cm farm trials over three years. Treatments in all trials are randomized and applied in planter width strips. For varieties, locations are used as replication with treatment numbers ranging from two to nine. For the nitrogen rate study, four treatments are replicated three times at each location. The treatments are hand harvested. Two forty foot samples are taken for plant population, biomass and grain yield from each treatment.

Coefficient of variations range from 3 to 7 percent with LSD at .05 for harvested grain of between three to four hundred weight. The growers are dependable, practical minded, realistic and appreciate the privilege of generating information that is useful to their profession. For most, seeing is believing. The information gained is willingly shared.

# TRANSFERRING KNOWLEDGE ABOUT ENERGY AND WATER MANAGEMENT TO GROWERS

Mark Freeman\* and Dale Handley, University of California Cooperative Extension, 1720 S. Maple Ave., Fresno, CA 93702

Much technology concerning efficient use of agricultural energy and water is available. However, this technology is underutilized by many growers because of inadequate training. This Extension program educates growers about evaluating irrigation systems, soil and water problems, irrigation scheduling, and energy use (of pumps). The program uses different communication tools to create awareness in growers, and then encourage adoption. These tools include in-depth surveys, condensed written material, small group discussions, and videotapes. The program also coordinates efforts among various governmental and private agencies.

# HYPERMEDIA INFORMATION SYSTEM TO DIAGNOSE PROBLEMS OF MACADAMIA NUT

Kent D. Kobayashi\*, H.C. Bittenbender, and Howard H. Hiraie, Department of Horticulture, University of Hawaii, Honolulu, HI 96822 USA

Growers and extension personnel need an easy to use method to help diagnose common problems of macadamia nut (*Macadamia integrifolia*). The Apple Macintosh® computer and the software HyperCard® provides one such system. We developed a hypermedia stack (file) that gives users the two options of helping diagnose a problem or providing additional information on a problem and its solution. Twenty-three of the most common problems of macadamia nut in Hawaii are covered including insects, diseases, nutritional deficiencies, harvest, postharvest handling, herbicide injury, poor flowering, and premature nut drop.

With the first option, the program asks the user on what part of the tree does the problem exist—leaves, flowers, nuts, branches, trunk, roots, or the entire tree. It then displays pictures of symptoms of problems specific to that part of the tree, and the user indicates whether these symptoms are present. The program gives the user additional information on the problem, its cause, conditions conducive to the problem, and possible solutions to resolve the problem. With the second option, i.e., if the user already knows the name of the problem, the additional information and solution are shown immediately. This program provides growers and extension personnel with a simple, quick, computerized tool to diagnose problems and access information and solutions.

# DRISCALC: A COMPUTER PROGRAM TO CALCULATE DRIS INDICES ON NUTRITIONAL ANALYSES.

Laurence A. Sistrunk\* and J. Benton Storey, Department of Horticultural Sciences, Texas A&M, University, College Station, TX 77843-2133.

Since DRIS calculations prove to be tedious for most researchers, a computer program was written to use test data from foliar analyses to compile DRIS norms for a population and using these norms, calculate the indices for each of 14 elements.

The data to be tested is first put into a record base format and stored as an ASCII file. When DRISCALC is run on IBM compatible microcomputers, this data is separated into two subpopulations based on the mean yield for the main population. The next procedure calculates the mean, the standard deviation (from the mean), and the variance for each subpopulation as well as the variance ratio (low yield/high yield) and the CV.

The *F* test for variance and the *student's t* test selects the norms (high population mean and CV'S). After construction of this temporary database, and unknown sample is entered into the program for testing. DRIS indices are calculated and several statistical options can be selected by the user. Hidden deficiencies can be found by the researcher or DRIS principles can be taught to students.

# PROTOTYPE COMPUTER SYSTEM FOR LANDSCAPE SITE MANAGEMENT CONTROLLED BY PHENOLOGICAL OBSERVATIONS

GiGi Siekkinen\* and Philip L. Carpenter, Department of Horticulture, Purdue University, West Lafayette, IN 47907.

Use of the computer and specialized software can provide flexibility needed to develop management schedules for landscape sites that differ in geographic location, size, and maintenance level. The major problem faced in developing this software is accommodating different climates and year-to-year variations in weather, which influence the optimum timing of many management activities. Using phenological observations of common plants to time maintenance activities rather than relying entirely upon calendar dates was investigated as a solution to this problem. A program that used a combination of phenological observations and calendar dates to schedule maintenance activities was developed. A system of maintenance activity

modules and landscape plant categories was used to produce a program flexible enough to be useful for a variety of landscape sites. This modular approach also permits future expansion of the program to include additional maintenance activities.

# EXPLAINING INCREASES IN PER CAPITA CONSUMPTION OF FRESH FRUITS

Gary Thompson\*, Russel Tronstad, and Michael Kilby, Department of Agriculture Economics, The University of Arizona, Tucson, Arizona, 85721.

During the last two decades, per capita consumption of fresh fruit has increased markedly. Although many believe that this increase has been caused by a heightened concern in health and diet, economic analyses indicates that changes in retail prices and increasing per capita incomes adequately explain the increased consumption of fresh fruit. Also, with more single households and women entering the labor force, the convenience factor of focal preparation has likely caused an increase in the consumption of fresh fruit. Substantial substitution between fresh fruit products has occurred: grapes and strawberries have increasingly substituted for citrus fruit, particularly grapefruit. These results suggest that relative prices for fresh fruits, increasing disposable income, and the changing demographic composition of households have prompted observed increases in the per capita consumption of fresh fruit.

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## 141 ORAL SESSION (Abstr. 658-665) VEGETABLE CROPS: CULTURE AND MANAGEMENT II

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# EFFECT OF A CRIMSON CLOVER GREEN MANURE ON YIELD AND QUALITY OF SWEET POTATO

Sharon R. Funderburk\* and Wanda W. Collins, Dept. of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Crimson clover (*Trifolium incarnatum* L.) was used as a N source for sweet potato [*Ipomoea batatas* (L.) Lam.]. Treatments were designed to compare estimated N delivery by clover incorporation amounts of N delivered by inorganic fertilizer. Plants were sampled every 14 days and sectioned into four parts: shoots, stem tips, fibrous and storage roots. Dry matter content was significantly influenced by time. Total plant dry matter was lowest in the highest inorganic N treatment. Nitrogen concentration (DWB) decreased over time and was highest in the highest inorganic N treatment. Similar vine weights were noted in N and clover treatments while number of storage roots per plant was unaffected by treatment as was weight per storage root, which increased linearly over time. No significant difference existed between the high and low N application treatment or late clover incorporation treatment in any grade of storage roots except culls, which were 90% lower in clover treatments than in N fertilizer treatments.

# NITROGEN RELATIONS IN A SWEET CORN/WHITE CLOVER LIVING MULCH CROPPING SYSTEM

Lee S. Altier\* and H. Christian Wien, Department of Vegetable Crops, Cornell University, Ithaca, NY 14853

In a two-year field experiment, sweet corn was intercropped with a perennial cover of white clover. The clover was suppressed after corn emergence by rototilling. The nitrogen exchange between the corn, clover, and soil was closely monitored. Soil sampling indicated the rate and amounts of mineralization of nitrogen from soil organic matter and clover. Fertilizer labelled with 15-N was used to assess contributions of nitrogen from the various sources.

Results from 1989 showed little nitrogen benefit to the corn from the clover. Content of 15-N in the corn indicated that non-fertilizer nitrogen uptake was similar in monocropped and intercropped corn treatments. Corn yields were correlated with the amount of nitrogen fertilizer applied.

## WINTER COVER CROPS IN LOW-INPUT VEGETABLE PRODUCTION

Kathryn E. Brunson\* and Sharad C. Phatak, Department of Horticulture, Coastal Plain Experiment Station, University of Georgia, Tifton, GA 31793

Cantaloupe (*Cucumis melo* L., cv. Hiline) were planted following over-wintering cover crops. In replicated field trials, stand development for 7 different cover crops and their effects on incidence of weeds, insects, diseases, and nematodes was assessed. Effects of cover crops on yield and quality of cantaloupe were evaluated. Cover crops evaluated were rye, crimson clover, lentils, subterranean clover, 'Vantage' vetch, mustard, a polyculture of all cover crops and control-fallow. No insecticides were applied and only two applications of fungicides were made. Fertilizer applications were significantly reduced. No differences among cover crops for any of pest nematodes were observed. Significant differences in populations of beneficial and pest insects were observed. Polyculture had the highest plant vigor rating. The highest marketable yield occurred following crimson clover.

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## NITROGEN, LIME AND MULCH EFFECT ON TOMATO PRODUCTION

James W. Paterson\*, Rutgers University, Rutgers Research & Development Center, RD 5, Box 232, Bridgeton, NJ 08302

The effectiveness of nitrogen, lime and mulch on the production of tomatoes (*Lycopersicon esculentum* Mill.) grown on a coastal plain sandy loam soil was investigated in 1989. Five rates of nitrogen, 0 to 180 kg ha<sup>-1</sup> in 45 kg ha<sup>-1</sup> increments, were applied to limed and unlimed soil. Each nitrogen treatment was split into bare ground and black plastic mulched plots. The highest total yield of quality tomatoes was produced with 90 kg ha<sup>-1</sup> of nitrogen. At all nitrogen rates, total yields of quality tomatoes produced in the limed areas were significantly greater than the crop produced in the unlimed acid areas. Increasing nitrogen above the 90 kg ha<sup>-1</sup> rate had no further significant increase on yields in the limed soil; however, the higher rates of nitrogen did significantly depress yields of quality tomatoes in the unlimed acid soil areas. The positive influence of liming was noted in the early, midseason and late harvests as well as in the total yields. Liming also had a positive influence on the size of the quality tomato while mulching had little to no effect on fruit size. Mulching also had only a modest effect on quality fruit yields. Soil test and tissue analysis results will also be discussed.

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## MINIMUM TILLAGE AND NITROGEN INTERACTIONS IN PRODUCTION OF FALL BROCCOLI

B. W. Roberts\* and Bob Cartwright, Wes Watkins Agricultural Research & Extension Center, Oklahoma State Univ., Box 128, Lane, Oklahoma 74555

Raised beds approximately 20 cm tall by 76 cm wide were formed on 1.8 m centers in the spring of 1988 and 1989. Beds were either left bare or seeded with rye (*Secale cereale*) or hairy vetch (*Vicia villosa*) at 84 or 45 kg ha<sup>-1</sup> respectively. All plots were sprayed with glyphosate in August of each year. In 1988, a 30 cm strip was tilled in the center of each bed. In 1989, there was no tillage or mowing.

The design was a randomized complete block with four levels of nitrogen (45, 90, 134, and 179 kg ha<sup>-1</sup>) at each soil cover. Broccoli seedlings were transplanted in double rows on 30 cm spacings into the plots each year in late August.

Height of the raised beds was maintained with both rye and vetch. Broccoli yields were highest in the bare soil treatments. In 1988, the lowest yield was with vetch, and in 1989 the lowest yield was with rye. There was a positive linear yield response to nitrogen. The number of heads harvested did not differ significantly between soil covers.

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## DEVELOPMENT OF A PLASTIC MULCH SYSTEM THAT CHANGES COLOR WITH SEASON

Dennis R. Decoteau\*, Heather H. Friend<sup>1</sup>, Dale E. Linvill<sup>2</sup>, and George Upton<sup>3</sup>, Department of Horticulture, <sup>2</sup>Department of Agricultural Engineering, Clemson University, Clemson, SC 29634-0375, and <sup>3</sup>Ampacet Corp., Flowery Branch, GA, 30542.

We have developed and field tested a plastic mulch system that changes color with season. The system uses a photodegradable polyethylene mulch placed on top of a degradable or nondegradable polyethylene mulch of a different color. As the top polyethylene mulch degrades with increasing exposure to sunlight, the color of the bottom polyethylene mulch is exposed. We have successfully evaluated the effects of a black photodegradable mulch placed on top of a white nondegradable

mulch on mulch color transition, soil temperatures under the mulch, and the production of spring planted tomatoes. The mulch color system affected soil temperatures and average tomato fruit size, but had no effect on number of fruit produced. We have also produced and are field testing a coextruded polyethylene mulch with the desired black and white photodegradable colored layers.

664

## QUALITY AND YIELD OF WHITE ASPARAGUS USING OPAQUE ROW COVERS

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Black and white plastic row covers were established over field-grown 'Jersey Giant' asparagus on 10 Mar 89. Season soil temps in uncovered, white, and black plastic treatments were 17.4, 15.9, and 16.8° C, respectively. Night air temp under plastics was about 1.4° C higher than no cover. Day temps under black plastic was about 10° C higher than no cover. Temps under white plastic were intermediate. Spears were cut for 7 weeks beginning on 27 March. Black plastic improved early yield only at the third cutting week. Marketable and total yield were improved with the use of plastics. Spear number/ha was not affected. Spear weight (after trimming to 15 cm length) was greater when grown under plastic, whereas spear length was reduced. There were no differences between treatments in spear fiber, but spears grown under plastic covers had higher soluble solids, sweetness rating, titratable acidity and nitrates and lower ascorbic acid, protein and phenolic levels than did uncovered spears. Very little chlorophyll and carotenoids were produced in the absence of light, but there was a color intensity difference between spears grown under the two different plastics.

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## THE EFFECT OF ROW COVERS ON THE YIELD OF THREE TOMATO CULTIVARS

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Three tomato varieties were evaluated for early and total yield using row covers. Tomatoes were planted three weeks earlier than the normal planting date and row cover treatments included; 1) slitted, clear polyethylene 2) floating, spunbonded, polypropylene and 3) bare, no row cover. 'Pilgrim', 'Celebrity' and 'Mountain Pride' were selected as early, mid-season and late varieties, respectively. Row covers were removed after three weeks at which time a second planting was made, representing the normal planting time. Slitted, clear, polyethylene row covers significantly increased early yields in all varieties as compared to the bare treatment. In addition, clear row covers resulted in higher early yields in 'Pilgrim' and 'Mountain Pride' than floating row covers. Despite row covers over 'Celebrity' and 'Mountain Pride', early yields were still not as great as the 'Pilgrim' cultivar without any row cover.

## 142 ORAL SESSION (Abstr. 666-672)

### CROSS-COMMODITY BIOTECHNOLOGY II/RFLPs

666

## RFLP ANALYSES OF PHASEOLUS INTERSPECIFIC HYBRIDS

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Interspecific hybridization between *Phaseolus vulgaris* and *P. coccineus* results in mature seeds or abnormal embryo formation depending on the direction of the cross. In addition, differential fertility and reversion to parental types occur in later progeny populations, accompanied by recurrence of various embryo types. Normal and abnormal embryos exhibited isozyme patterns resembling *P. vulgaris* and *P. coccineus* parents respectively, suggesting that developmental abnormalities may be associated with specific combinations of parental genes. RFLP between parental species was examined and probes were selected for analyses of F<sub>2</sub> populations. Differential transmission of alleles occurred for some RFLP markers. Statistical analyses were applied to detect possible association between probes and abnormal developmental events. The high incidence of interspecific polymorphism will also facilitate the construction of a linkage map in *Phaseolus*.

# PROGRESS TOWARD DEVELOPMENT OF AN RFLP MAP FOR CUCUMBER

Wayne Kennard\*, Arian Dijkhuizen, Michael Havey, and Jack Staub, USDA/ARS and Department of Horticulture, University of Wisconsin, Madison, WI 53706

The analysis of genetic linkage in cucumber (*Cucumis sativus*) has primarily involved morphological and disease resistance markers. Linkage analysis in cucumber would benefit from more markers. Restriction fragment length polymorphisms (RFLPs) can occur in relatively large numbers within a single segregating family. Research is presently underway to construct an RFLP map of cucumber. Pst I partial genomic and cDNA libraries of cucumber have been constructed as sources of probes for RFLP analysis. Cucumber DNA from 16 accessions of cucumber and one accession of *C. sativus* var. hardwickii were digested with either of two restriction enzymes (EcoR I and Hind III). This germplasm allows for the assessment of the variability for RFLPs in cucumber and will provide the parents for map construction.

# DNA FINGERPRINTING OF ROSE CULTIVARS BY RESTRICTION FRAGMENT LENGTH POLYMORPHISMS

Sriyani Rajapakse\*, Mark Hubbard<sup>1</sup>, Albert Abbott<sup>2</sup>, John Kelly<sup>1</sup> and Robert Ballard<sup>1</sup>, <sup>1</sup>Department of Horticulture and <sup>2</sup>Department of Biological Sciences, Clemson University, Clemson, SC 29634-0375

Restricted Fragment Length Polymorphisms (RFLPs) were investigated in closely and distantly related rose cultivars as means of identifying those cultivars for the purpose of patent protection. A random genomic DNA library was constructed using the cultivar 'Confection' and the *Escherichia Coli* strain JM83 plasmid vector pUC8. Clones with interspersed repeat sequences were then identified by hybridizing restriction digested cloned DNA fragments with nick translated genomic DNA of the rose cultivar 'Confection'. Hybridization positive clones were screened for polymorphism by Southern hybridization on restriction digested genomic DNA of various rose cultivars. About 75% of the interspersed repeat copy probes screened revealed polymorphisms. We have identified probes that give fingerprint patterns for rose cultivars. From this information, a dichotomous key which differentiates the rose cultivars examined was prepared. Current research involves screening more probes and rose cultivars for polymorphisms, and examining single copy probes for potential use in RFLP genetic linkage map construction in roses.

# PRELIMINARY RESULTS OF PHYLOGENETIC STUDIES WITHIN THE GENUS *ROSA* (ROSACEAE).

Mark Hubbard\*, John Kelly, Sriyani Rajapakse, Robert Ballard and Albert Abbott, Departments of Horticulture and Biological Sciences, Clemson University, Clemson, SC 29634-0375

We have initiated a phylogenetic study using restriction fragment length polymorphisms to examine nuclear DNA variation in a number of *Rosa* species. Random genomic clones were isolated from the cultivar 'Confection'. To generate these clones, genomic DNA was digested with the restriction enzymes *Hind* III and *Eco* RI and the resulting fragments cloned into a pUC8 plasmid and transformed into the *E. coli* bacterial strain JM83. Individual clones from the DNA library were screened for polymorphism by Southern hybridization methods. Those clones displaying polymorphisms were used in combination with one, two, or three restriction enzymes to identify different size restriction fragments. Each fragment was treated as a unit character and was used to generate a phylogenetic tree using the computer program "Phylogenetic Analysis Using Parsimony" (PAUP version 3.0). Results of the studies on the amount of genetic diversity and phylogenetic affinities of *Rosa* species among the different sections of the subgenus *Rosa* will be presented.

# VARIABILITY FOR RESTRICTION FRAGMENT LENGTH POLYMORPHISMS IN THE CHLOROPLAST AND NUCLEAR GENOME OF ALLIUM SPECIES.

Michael J. Havey, USDA/ARS, Department of Horticulture, University of Wisconsin, Madison, WI 53706

Restriction fragment length polymorphisms (RFLPs) in the chloroplast and nuclear genome are useful for estimation of phylogenetic relationships. Fifteen mutations at restriction enzyme sites in the chloroplast DNA were discovered. The wild species *A. oschaninii* and *A. vavilovii* were identical to *A. cepa* for all mutations. These species represent sources of wild germplasm closely related to the bulb onion. Nuclear RFLPs are now being used to estimate the genetic distances between accessions of *A. oschaninii*, *A. vavilovii*, and open-pollinated populations of the cultivated bulb onion.

# PHYLOGENETIC RELATIONSHIPS OF PRUNUS SPECIES IN THE AMYGDALUS SUBGENUS.

Jose X. Chaparro\*, Ronald R. Sederoff, Dennis J. Werner<sup>1</sup>, Departments of Horticultural Science<sup>1</sup> and Forestry<sup>2</sup>, N.C.S.U. Raleigh, NC. 27695

Total cellular DNA has been extracted from leaves and/or seed of *Prunus dulcis*, *P. persica*, *P. mira*, *P. davidiana*, *P. persica* subsp. *ferganensis*, and *P. triloba*. Chloroplast restriction fragments have been visualized by Southern blot analysis using heterologous probes from a petunia chloroplast library. Analysis of preliminary data separates the species into three groups. The first contains *P. dulcis*, *P. mira*, and *P. davidiana*; the second *P. kansuensis*, *P. persica*, and *P. persica* subsp. *ferganensis*; and the third *P. triloba*.

PCR amplification using oligos for cytosolic glyceraldehyde-3-phosphate dehydrogenase yields genomic fragments approximately 1kb in size from *P. dulcis* and *P. triloba*. Sequence analysis will be performed to determine species relationships at the gene level.

# CHLOROPLAST RESTRICTION FRAGMENT VARIABILITY IN RASPBERRY

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Cultivated raspberries may include North American red raspberry (*Rubus idaeus strigosus* Michx), European red raspberry (*R. idaeus vulgatus* Arrhen.) or black raspberry (*R. occidentalis* in their pedigrees. Twenty-one raspberry clones were investigated using chloroplast restriction fragment length polymorphisms to determine the cytoplasm type and the amount of cytoplasmic diversity among these selected clones. The raspberry clones were selected representing North American red raspberry, European red raspberry, black raspberry and cultivars with divergent maternal lineages. Total cellular DNA was probed with two <sup>32</sup>P-labelled fragments of tomato chloroplast DNA. Probe-restriction enzyme combinations were selected which discriminated between representatives of the two red raspberry subspecies. Raspberry clones were grouped according to the chloroplast restriction fragment patterns. The composition of the groups was compared with their pedigrees.

## 143 ORAL SESSION (Abstr. 673-678) FLORICULTURE: CULTURE AND MANAGEMENT

# TEMPERATURE, TRANSPLANT TIME, AND PLUG SIZE EFFECTS ON GROWTH AND DEVELOPMENT OF PANSY, PETUNIA, VINCA, AND IMPATIENS

Abdulrhman I. Al-hemaid\* and David S. Koranski, Department of Horticulture, Iowa State University, Ames, Iowa 50011

Petunia 'Red Flash', Vinca 'Little Blanch', Pansy 'Majestic Giant Purple', and Impatiens 'Super Elf Red' plugs were held in the greenhouse after they reached the saleable size in 200, 406, 512, and 800 for 1 to 3 weeks. Pansy plugs were held in coolers at 40, 50, or 60F under fluorescent light for 16 hrs photoperiod for 1 to 3 weeks in 200, 406, 512, or 800 plug trays. All plants were transplanted weekly and were grown in the greenhouse until flowering and data were collected. For plants held in the greenhouse, plants were affected by transplanting time. As the holding time increased the final height, diameter, flower number, and fresh and dry weight of plants decreased. The flowering time was delayed by increase the holding time, regardless of plant variety. As cell size decreased, plant height, diameter, flower number, and fresh and dry weight decreased. For plants held in the coolers, the flowering time was delayed by the transplant time, regardless of cooler temperatures. Plant quality was not affected by the treatment. The height, diameter, flowers number, and fresh and dry weight of plants showed a little effects by temperatures, cell size, and transplanting time.

674

# THE EFFECTS OF CARBON DIOXIDE ENRICHMENT ON PRODUCTION AND POSTHARVEST CHARACTERISTICS OF POTTED ROSES (*Rosa* $\times$ *hybrida* 'Meijikatar')

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Potted *Rosa*  $\times$  *hybrida* 'Meijikatar' plants were produced at 350, 700, and 1050  $\mu\text{l-liter}^{-1}\text{CO}_2$ . At a stage of development where half of the flowers showed color, plants were placed into simulated shipping incubators for 5 days at 4 or 16 C.

Increased  $\text{CO}_2$  levels resulted in shorter production time, increased root dry weight, increased plant height, and reduced total chlorophyll in the upper leaves of the plants. Upon removal from simulated shipping, the number of etiolated shoots per plant increased with increased  $\text{CO}_2$  concentration. After 5 days in a simulated interior environment, higher shipping temperatures induced more leaf chlorosis, but there were no differences in leaf chlorosis due to  $\text{CO}_2$  enrichment.

675

# GROWTH RESPONSE OF SNAPDRAGON ANTIRRHINUM MAJUS TO NIGHT AIR TEMPERATURES AND ELEVATED ROOT-ZONE TEMPERATURES

Khin San Wai\* and S.E. Newman, Department of Horticulture, Mississippi State University, Mississippi State, MS 38762

The response of *Antirrhinum majus* (snapdragon) cultivars ('Tampicoi' and 'Rainier White') to night air temperatures (10C and 20C) and elevated root-zone temperature (26C and ambient) was studied. Height of plants grown with a heated root-zone were greater, compared to unheated at both night temperatures for both cultivars. Shoot dry weight of 'Tampicoi' plants was reduced by heated root-zone temperature at 20C night air temperature. Raceme length was greater with heated root-zone temperature compared to unheated at 10C night air temperature. Days to flower were shorter with heated compared to unheated root-zone at both night air temperatures for both cultivars. Stomatal diffusive resistance was greater on plants with unheated compared to heated root-zone temperature at 10C night air temperature for 'Rainier White'.

676

# COMPARISON OF NINE PLANTING MEDIA FOR FORCING SWAZILAND AND DUTCH-GROWN AMARYLLIS (HIPPEASTRUM)

A. A. De Hertogh and M. Tilley\*, Department of Horticultural Science, N.C. State University, Raleigh, NC, 27695-7609

Almost all Amaryllis (*Hippeastrum*) forced in the U.S. and Canada by either homeowners or commercial forcers are grown overseas. In order to comply with USDA/APHIS plant quarantine regulations, all bulbs must be free of soil. Thus, they are washed once or twice prior to packing and shipping. As a result of this treatment, the bulbs arrive with only basal roots and no secondary roots. Therefore, over the past year, 2 hand made mixes and 7 commercially prepared mixes were evaluated using 2 cultivars each of Swaziland- and Dutch-grown bulbs. The effects of these media on forcing characteristics, e.g. total plant height, leaf length, flower number, etc. were examined. Also, the influence of the various media on basal root growth and formation of new secondary roots was measured. The results of these 2 studies will be presented.

677

# LIGHT, TEMPERATURE AND PHOTOPERIOD AFFECT THE USEFULNESS OF *OXYPETALUM CAERULEUM*, *TWEEDIA*, AS A CUT FLOWER CROP.

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A progressive increase in temperature from 14 to 30C resulted in linear increases in stem length and node number and decreases in stem diameter and stem strength. Higher temperatures also resulted in additional flower abortion, reduced time to flowering and fewer flowering stems per inflorescence. Reduction in the photosynthetic photon flux (PPF) from 695 to 315  $\mu\text{mole m}^{-2}\text{s}^{-1}$  had similar effects as increasing the temperature on vegetative parameters but had little effect on reproductive parameters. The rate of stem elongation was greatest at low PPF for all temperatures and at high temperature for all PPF treatments. Net photosynthesis rose between 14 and 22C and

declined at 30C for all PPF treatments. Long photoperiods (12, 14 hr.) resulted in longer internodes, longer stems and more flowers per cyme than short photoperiods (8, 10 hr) but photoperiod had little effect on flowering time.

678

# STORAGE TIME AND FORCING TEMPERATURE EFFECTS ON GROWTH AND FLOWERING OF DWARF ASIATIC LILIES

Xuri Zhang\*, David J. Beattie, and John W. White, Department of Horticulture, The Pennsylvania State University, University Park, PA 16802

Commercially cooled bulbs of five genetically dwarf Asiatic hybrid lilies were stored frozen at -2 C. Every 4 weeks for a total of 40 weeks, they were potted and forced in controlled environment chambers at 10, 15, 20, or 25 C. For each temperature, days from the time of potting to shoot emergence, visible bud appearance, and anthesis generally decreased as storage time increased. The number of flowers per plant and plant height were not significantly affected by storage time. Compared with those at 15, 20, or 25 C, plants at 10 C required significantly more time from potting to shoot emergence, visible bud, and anthesis. However, the temperature effects on forcing time were not linear. There was a 30-50 day decrease from potting to anthesis when temperature was increased from 10 to 15 C, but there was only a decrease of about 10 days when temperature was increased from 15 to 20 C. In contrast, there was no significant difference in forcing time between plants at 20 and 25 C. This indicates there is no need to force these lilies above 20 C. Plants at 25 C had more aborted flower buds than those at 10, 15, or 20 C. Plants at 10 C were taller than those at 15, 20, or 25 C.

## 144 ORAL SESSION (Abstr. 679-686) CROSS-COMMODITY NUTRITION I

679

# PHOSPHATE FERTILIZER INFLUENCES PHYTOAVAILABILITY OF SOIL ARSENIC AND LEAD TO APRICOT (*Prunus armeniaca*)

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Fruit trees grown in soils contaminated with lead arsenate (PbHAsO<sub>4</sub>) pesticide residues are subject to arsenic (As) phytotoxicity, a condition that may be exacerbated by use of phosphate fertilizers. A potted soil experiment was conducted to examine the influence of phosphate fertilizer on accumulation of As and lead (Pb) in apricot (*Prunus armeniaca*) seedlings grown in a lead arsenate-contaminated Burch loam soil. Treatments were fertilizer source (mono-ammonium phosphate [MAP], ammonium hydrogen sulfate [AHS]) and rate (0, 8.7, 17.4, and 26.1 -mmol/liter), and presence/absence of lead, arsenate contamination (231 -mg/kg soil). Plant biomass accumulation was reduced by lead arsenate presence and by high fertilizer rates, the latter due to soil salinization. Phytoaccumulation of As was enhanced by lead arsenate presence and by increasing MAP rate but was not influenced by AHS rate, salinity, or acidity of soil. Phytoaccumulation of Pb was enhanced by lead arsenate presence but was not influenced by fertilizer treatment.

680

# THE INFLUENCE OF SOIL CALCIUM LEVEL ON GROWTH AND YIELD OF WATERMELON AND CALCIUM CONCENTRATION OF WATERMELON RIND TISSUE

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Three cultivars of watermelon (*Citrullus lanatus*), 'Crimson Sweet', 'Charleston Gray' and 'Tri-X Seedless' were grown in combination with 4 levels of soil applied calcium (0, 280, 560, 1120 kg Ca/ha). Gypsum was incorporated into 6 m plots on 5 m centers then covered with black plastic mulch. Irrigation requirements were provided through a hi-wall drip system and soil water status monitored with tensiometers. Transplants were spaced 1.2 m apart in-row spacing allowing for 5 plants per plot and replicated 3 times. Melons were harvested at 7, 14, 21 days from anthesis and at full maturity. Rind tissue was analyzed for total and extractable Ca, Mg, K, Mn, Zn and Fe. Leaf samples were taken 6 weeks from transplanting for similar analysis. Yield, vine growth and the incidence of blossom-end rot were recorded. The study was conducted at 2 locations during the 1989 and 1990 growing seasons. Data will be presented at the meeting.

681

INFLUENCE OF TWO CO<sub>2</sub>SOURCES ON SOIL pH AND ABOVE GROUND CO<sub>2</sub>LEVELS

H. K. Cahn, F. D. Moore III\*, and H. G. Hughes, Department of Horticulture, Colorado State University, Fort Collins, CO 80523

Carbon dioxide concentrations measured within and above a strawberry plant (*Fragaria × ananassa*) canopy were significantly higher during enrichment with carbonated water or 900 kg CO<sub>2</sub>/ha·hr applied as gas. Both sources were applied to the base of the plants through drip irrigation tubing under a black polyethylene mulch (0.025 mm) covering or over bare unmulched soil. Mulch affected the concentrations at the top of the strawberry canopy differently for the two sources of CO<sub>2</sub> enrichment. Carbonated water was found to reduce the pH of the calcareous soil at the research site (pH 8.2) during and between irrigations. The greatest single pH reduction was 2.6 pH units during irrigation measured in mulched soil; significant soil pH reductions were detected as long as 28 days after irrigation underneath the mulch. Soil pH "duration" below pH 7.4 was 70% greater considering mulch and carbonated water vs. no mulch and carbonated water irrigation.

682

## THE ROLE OF BORON IN FLOWERING AND FRUIT SET

Patrick H. Brown\*, Louise Ferguson and Geno Picchioni, Department of Pomology, University of California, Davis, CA 95616-8683

The uptake and distribution of foliar and soil applied boron has been followed in a seven year old pistachio orchard by utilizing <sup>10</sup>B isotope dilution techniques and ICP-MS determination. In conjunction with these uptake studies, in-vivo and in-vitro measurements of pollination and fruit set have been used to determine the role of boron in flowering and fruit set.

Foliar applications of boron (1, 2.5 and 5 kg/400 l) resulted in improved fruit set when compared to control trees receiving no supplemental B even when tissue B levels in these control trees appeared adequate (>60 µg/g dwt). Results indicate that B applied to male trees in the late dormant phase (February) is effective in enhancing in-vitro pollen germination by as much as 50%. Movement of B into flower buds and fruit clusters was verified using <sup>10</sup>B techniques thus demonstrating the potential usefulness of this technique in correcting incipient B deficiency. A possible role of B in the flowering and fruiting process is discussed.

683

## SYMPTOM DEVELOPMENT AND TISSUE CONCENTRATIONS OF CHLORIDE AND BORON TOXICITY IN KIWIFRUIT Janine Hasey\*, University of California Cooperative Extension, Yuba City, CA 95991, K. Uriu and J. Pearson, Department of Pomology, University of California, Davis, CA 95616.

Chloride and boron toxicity symptoms and tissue concentrations were characterized and distinguished in kiwifruit. Dormant cane, bud, emerging leaves, blade and petiole samples were taken from February through October 1989 from three vineyards - a high chloride, a high boron and a low boron, low chloride control. Chloride toxicity symptoms started showing in early summer on basal leaves. By late summer, necrosis symptoms were on mid-shoot and leaves near the shoot terminal. In boron toxicity, interveinal chlorotic areas appeared first followed by marginal necrosis. Symptoms were seen on basal leaves in early spring, progressively affecting upper leaves by harvest. The high chloride vineyard accumulated chloride from early spring with the petiole concentrating more chloride than the blade. In the high boron vineyard, boron increased greatly in the blade but not in the petiole. Another sampling procedure other than mid-season leaf samples could be emerging leaves for detecting high chloride and dormant cane tips, buds or emerging leaves for high boron.

684

## EVALUATION OF A CONTAINERIZED GRADIENT CONCEPT AS A SUSTAINABLE PRODUCTION SYSTEM FOR TOMATOES

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During the 1970s a mulched gradient concept was adapted by the Florida vegetable industry and the average yield of tomatoes was doubled. Currently, because of potential water restrictions and society's increasing concerns about environmental pollution, a containerized gradient concept is being evaluated. Containers, media and nutrient/water balance are major components being evaluated to maximize water use efficiency and minimize pollution and, at the same time, maintain or increase the existing competitive excellence. Three seasons

of results indicate tomato yields equivalent to those produced commercially; water use has averaged 4 liters/plant/day (about 1/5 to 1/10 that used commercially); and leaching, fumigation and plastic mulches have been eliminated. The concept as a sustainable production system is considered commercially feasible.

685

## VA MYCORRHIZAL INFLUENCE ON GROWTH AND MINERAL UPTAKE OF POTATO

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The growth response of potato to infection by vesicular-arbuscular mycorrhizal fungi (VAM) (*Glomus dimorphicum*, *G. intraradices*, and *G. mosseae*), at increasing levels of soil phosphorus (P), was related to VAM-altered mineral status of the plant. In addition, the morphological development of the VAM was characterized using light and scanning electron microscopy.

Four weeks after inoculation, arbuscules and coiled hyphae were the predominate fungal structures within the roots, however, vesicle development increased steadily over the remainder of the 12 week growth period. As expected, the percent infection of roots by VAM decreased with increasing soil-P level. Leaf area, relative growth rate (RGR), lateral branching and root dry weight were increased by VAM, although the relative-response diminished with increasing soil-P level. A similar response to VAM-infection was evident for the concentration of and total shoot N, P and K. Examination of the shoot N status indicated that VAM influenced the rates at which the plant was partitioning N into various N pools. But again, differences between non-VAM and VAM plants tended to decrease with increasing soil-P level. These results indicate that VAM modification of dry matter accumulation and nutrient uptake is mostly a consequence of the alleviation of P-deficiency of the plant and the improved growth of roots, allowing increased mineral absorption.

686

## NITROGEN NUTRITION OF CITRUS NURSERY STOCK IN PINE BARK SUBSTRATES.

John D. Lea-Cox\* and Irwin E. Smith., Dept. of Horticultural Science, University of Natal, Pietermaritzburg, 3200. South Africa.

Pine bark is utilized as a substrate in citrus nurseries in South Africa. The Nitrogen (N) content of pine bark is inherently low, and due to the volatility of N, must be supplied on a continual basis to ensure optimum growth rates of young citrus nursery stock. Three citrus rootstock (rough lemon, carizzo citrange and cleopatra mandarin) showed no difference in stem diameter or total dry mass (TDM) when supplied N at concentrations between 25 and 200 mg · l<sup>-1</sup> N in the nutrient solution over a 12 month growing period. Free leaf arginine increased when N was supplied at 400 mg · l<sup>-1</sup> N. The form of N affected the growth of rough lemon. High NH<sub>4</sub>-N:NO<sub>3</sub>-N (75:25) ratios decreased TDM when Sulfur (S) was absent from the nutrient solution, but not if S was present. Free arginine increased in leaves at high NH<sub>4</sub>-N (No S) ratios, but not at high NH<sub>4</sub>-N (S supplied) ratios. Free leaf arginine was correlated with free leaf ammonia. These results have important implications for reducing the concentration of N in nutrient solutions used in citrus nurseries and may indicate that higher NH<sub>4</sub>-N ratios can be used when adequate S is also supplied.

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## 175 ORAL SESSION (Abstr. 687-693)

### FRUIT CROPS:

### CULTURE AND MANAGEMENT IV

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687

## THE EFFECT OF DEFOLIATION ON STRAWBERRY FRUITING RESPONSE

E. E. Albrechts\*, C. M. Howard, and C. K. Chandler University of Florida, IFAS, Agricultural Research &amp; Education Center, 13138 Lewis Gallagher Rd., Dover, FL 33527.

During 2 seasons, defoliated and non-defoliated strawberry plants were evaluated for their fruiting response using the annual hill cultural system in Dover, FL. Partially dormant Canadian grown 'Chandler' and non-dormant locally grown FL



breeding line 79-1126 were grown the first season. Locally grown 'Dover' was added the second season. Total yields of all clones were reduced with foliage removed. Monthly yields were reduced the first season with FL 79-1126 defoliated plants, but only the April yield of defoliated 'Chandler' was reduced. December, January, March, and total yields of defoliated plants from all clones were reduced the second season. Average seasonal fruit weight was reduced the second season with locally grown defoliated plants. During the second season the percent marketable fruit of 'Chandler' and FL 79-1126 was greater with the defoliated plants.

688

#### TRELLISING TO IMPROVE MANUAL HARVEST EFFICIENCY AND TO ENABLE MECHANICAL HARVEST OF RUBUS FOR FRESH FRUIT MARKETS.

Herbert D. Stiles, VPI&SU, Southern Piedmont Agricultural Experiment Station, Blackstone, VA 23824

Three different "shift-trellises" were designed to localize the fruiting zone and to separate it from vegetative structures. This allows efficient manual harvests by making berries more visible and easier to reach. It improves the quality of manual harvest conditions by reducing human contact with thorns (i.e., prickles).

Better definition of the fruiting zone's dimensions and location, important factors in mechanical harvesting, is possible with these systems. One system allows horizontal placement of the fruiting zone as in the Lincoln Canopy System, but with an inverted orientation of the fruiting shoots. Inverted orientation of fruiting shoots will shorten the distance to the mechanical harvester's collector surface. This changed juxtaposition among trellis components, floricanes and fruiting shoots will eliminate most obstacles against which berries might impinge during their fall to the collector surface. A new kind of agitator may be required to effect fruit removal in this system.

689

#### TISSUE-CULTURED RASPBERRY PLANT ESTABLISHMENT

David Trinka and Marvin Pritts\*, Department of Pomology, Cornell University, Ithaca, NY 14853

Tissue-cultured (TC) plantlets are becoming the preferred planting stock for raspberry growers because of their uniformity, ease of handling, general vigor and disease status. However, previous studies have shown that TC plants are sensitive to many preemergent herbicides and to cultivation within several weeks after planting. In addition, little is unknown about handling practices for TC plants relative to conventionally propagated plants during the establishment year. We subjected TC raspberries cv. Heritage to different management practices during the establishment year and monitored plant performance over two years to determine if better recommendations could be made for TC plantlets. One set of management practices examined weed control, and treatments included straw mulch, black polyethylene mulch, white on black polyethylene mulch, napropamide herbicide, simazine herbicide, hand weeding, and an untreated control. A second factor was fertilizer placement, with calcium nitrate applied on the soil surface around the plant or placed in the planting hole. A third factor was row cover application during the first six weeks of growth. Significant differences in soil moisture, soil temperature, plant growth, and yield occurred among the 22 treatments, and results suggested that TC plants require a different set of management practices than conventional propagules.

690

#### CRANBERRY FERTILITY RESEARCH: ESTABLISHING THE DATABASE NEEDED TO SUPPORT EFFICIENT EXPERIMENTATION IN THE 90'S.

Carolyn DeMoranville\*, University of Massachusetts Cranberry Experiment Station, P. O. Box 569, East Wareham, MA 02538.

With dwindling funding for horticultural research, the need to conduct experiments which are the most efficient in terms of resource (including personnel) utilization becomes apparent. Research on minor crops such as cranberry (*Vaccinium macrocarpon*, Ait.) has been particularly hard-hit by the funding crunch. A study to generate a large database as the basis for future experimental design was initiated in 1986 for the variety 'Early

Black' (60% of MA commercial acreage). Seasonal nutrient levels for all tissues, patterns of biomass development, components of yield, and fruit development were included. In 1989, the study was expanded to include a comparison of 6 MA varieties grown under the same cultural and environmental condition. A portion of the database will be presented and its implementation to increase field experiment efficiency will be discussed.

691

#### EFFECT OF HEDGING ON FROST TOLERANCE OF 'DELITE' RABBITEYE BLUEBERRIES

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A late spring frost, -2°C on 10 Mar 1989, destroyed all blossoms on 'Delite' rabbiteye blueberries. To determine the effect of hedging as a rejuvenation method, six-year-old 'Delite' plants were pruned on 26 April 1989. All branches were removed at 46 cm from ground level. Unpruned control plants were approximately 184 cm tall. On 21 Mar 1990 a frost of -2°C occurred. Two days later bud damage was assessed on three wood types: spring-old (SO), spring growth on old, weak wood; spring-new (SN), spring growth on vigorous 1-year-old shoots; and fall (F), postharvest late summer/fall growth. Buds were identified as to their stage of development. Buds formed on both types of spring wood were further developed than those on fall wood. As flower stage advanced frost damage increased. Blossoms on fall growth were most frost tolerant and SN was more hardy than SO. Subsequent yields will be determined and reported.

692

#### RETENTION OF LEAF AREA INFLUENCES FIELD GRAFTING OF CONCORD GRAPEVINES

Thomas J. Zabadal\* Michigan State University, Southwest Michigan Research & Extension Center, Benton Harbor, MI 49022

Field grafting of the Concord variety (*V. labruscana*) when using t-bud, chip bud or sidewhip grafting is typically less successful than when these grafting methods are applied to several European (*V. vinifera*) and European-American hybrid varieties. Sap flooding is one cause of failure of field grafts. Although trunk slashing basal to field grafts is used to control such sap flooding, it was not effective on Concord vines. Therefore, a strategy to reduce sap flooding of graft unions on Concord vines by increasing transpiration was evaluated. Additional leaf area was retained at the time of field grafting by using the following approaches either alone or in combination: (a) delaying trunk decapitation until several weeks after grafting, (b) retaining a trunk renewal cane and (c) retention of a second, ungrafted trunk. All treatments significantly increased the success rate for the t-bud (88% vs. 63%), chip bud (85% vs. 36%) and sidewhip (90% vs. 48%) grafting methods. Concord vines develop modest leaf area from base buds at the time of field grafting when compared to many other grape varieties. These results suggest that this factor influences the application of certain field grafting methods to this variety.

693

#### ENHANCING BUDBREAK IN DESERT-GROWN TABLE GRAPES

Larry E. Williams, Rudy Neja\* and Lori Yates, University of California, Davis, CA 95616.

A study was conducted to determine the effects of various cultural practices on enhancing earlier and more uniform budbreak of Perlette grapevines grown in the Coachella Valley of California. Post-harvest irrigation treatments were imposed approximately July 1 for three consecutive years. This included cut-off dates (Sept 15 and Nov 15) and various irrigation amounts based upon a standard treatment in which continued vegetative growth was inhibited. The application of hydrogen cyanamide or lack of also was included in the experimental design. In 1989 and 1990, the early irrigation cutoff date resulted in earlier dates of budbreak compared to the late cutoff. Vines irrigated with the most water had delayed budbreak compared with those irrigated with less. There were significant ( $p < 0.05$ ) interactions between irrigation amounts and cyanamide applications. The results indicate that the amount and timing of post-harvest irrigations in conjunction with cyanamide will promote earlier and more uniform budbreak of vines grown in the desert.

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## 176 ORAL SESSION (Abstr. 694–700) CROSS-COMMODITY NUTRITION II

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694

### TIMING OF OSMOCOTE REAPPLICATION ON GROWTH OF CONTAINERIZED 'HELLERI' HOLLY.

Robert D. Wright,\* Mike Witt, and Carol Leda, Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0327

*Ilex crenata* 'Helleri' rooted cuttings were container grown for one summer with Osmocote 18N-2.6P-7.6K which was reapplied at different times. Beginning in April and every month thereafter until October, five plants were harvested and separated into roots and shoots for dry weight and nitrogen (N) analysis. Plants that had received a reapplication of Osmocote in June or July were larger in October than those that received no supplemental fertilizer. If reapplication occurred in August or September, no influence on growth was realized. Plants that were not supplemented had lower percent tissue and medium solution N. These data demonstrate that tissue nutrient analysis as well as the medium nutrient levels extracted with the pour-through procedure can be used to determine when reapplication of a slow-release fertilizer is necessary to promote optimal growth.

695

### MICRONUTRIENT SUPPLY FROM SULFATE SOURCES IN A PINE BARK MEDIUM

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

Amending soilless media with micronutrients is a routine nursery practice. The objective of this research was to determine the micronutrient status of pine bark amended with two sulfate micronutrient sources and a control (unmended). Lined pine bark was unamended, amended with Ironite (1 and 2 g/l), or Micromax (1g/l). Bark was irrigated with distilled water in amounts equivalent to 30, 60, 90, and 120 irrigations (.63 cm per irrigation). Following irrigations, Cu, Fe, Mn, and Zn were extracted with a modified saturated media extract method using .001M DPTA as the extractant. Irrigation amount had no effect on Cu and Mn concentrations which were greater in the Micromax treatment than the Ironite or control treatments. A micronutrient source  $\times$  irrigation interaction existed for Fe and Zn concentrations requiring regression analysis. In general, slope values indicating the decrease in micronutrient values with increasing irrigations were quite low ( $\leq .001$ ) for each source. Regardless of irrigation amount, Fe and Zn concentrations were similar for amended and unamended bark.

696

### SHRINKAGE IN TERNARY MIXES OF CONTAINER MEDIA

Silvia Bures\* and Franklin A. Pokorny, Department of Horticulture, University of Georgia, Athens, GA 30602

An equation for predicting shrinkage in 3-component (ternary) container media was devised. The predictive equation was tested using experimental data obtained from sets of mixtures of milled pine bark, sand, and calcined clay. Each set consisted of 66 different combinations of the experimental components. Actual shrinkage data was correlated with theoretical values calculated from the predictive model. Results of the experiment suggest that shrinkage can be used as a factor with linear programming techniques.

697

### EXPANDED SHALE AS A POTTING MEDIUM COMPONENT FOR BEDDING PLANTS

Mark A. Nash\*, Tim P. Brubaker, and Billy W. Hipp, Texas A&M University Research and Extension Center, Dallas, Texas 75252

Expanded shale and peat moss were mixed in 5 ratios and evaluated as potting media for Petunia and Impatiens. Two grades of shale (coarse and fine) were used. Bulk density increased linearly with increasing shale whereas total pore space and container capacity increased linearly with increasing peat. Air space of peat-fine shale was consistently lower than that of peat-coarse shale when the peat/shale ratio was the same. Container capacity of peat-fine

shale was consistently higher than that of peat-coarse shale when the peat/shale ratio was the same. Growth and quality of both bedding plants increased quadratically with increasing peat in peat-coarse shale and increased linearly with increasing peat in peat-fine shale. Highest growth and quality of both plants were found in peat-coarse shale media with at least 50% peat and in peat-fine shale media with at least 75% peat.

698

### FERTILIZATION OF CHRISTMAS CACTUS

Richard T. Poole\* and Charles A. Conover, Central Florida Research and Education Center-Apopka, University of Florida, IFAS, 2807 Binion Road, Apopka, FL 32703

Three factorial experiments with various combinations of N, P or K were conducted over 3 years with *Schlumbergera truncata* (Haw.) Moran. Blooming was influenced by fertilization. Number of blooms was reduced by both low and high fertilization. Nitrogen appeared to be the most influential element, with high levels decreasing time to bloom and number of blooms. Potassium had no effect, and an increase in phosphorus decreased time to bloom and number of blooms.

699

### PRETRANSPLANT NO<sub>3</sub>:NH<sub>4</sub> RATIO AND SUPPLEMENTAL CALCIUM INFLUENCE WATERMELON SEEDLING GROWTH, MINERAL COMPOSITION, AND YIELD

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The effects of supplemental Ca and varying NO<sub>3</sub>:NH<sub>4</sub> ratios on transplant growth and NH<sub>4</sub>-N utilization were studied using watermelon (*Citrullus vulgaris* L. 'Crimson Sweet') seeded in plastic multicell trays. The growing media consisted of a commercial peat mix amended with CaCO<sub>3</sub> (10% w/v). Fertiligation with five NO<sub>3</sub>:NH<sub>4</sub> ratios and five levels of supplemental Ca (4, 8, 12, 16 mmol.) was applied daily in factorial combinations. The highest NO<sub>3</sub>:NH<sub>4</sub> ratio produced greatest shoot dry weight, shoot N, and shoot NO<sub>3</sub>-N and K concentrations. Increasing NH<sub>4</sub> and Ca decreased media pH and increased EC. After 21 days, supplemental Ca decreased shoot N and dry weight, but after 28 days had no effect. Additional Ca increased shoot Ca but decreased Mg and K. Supplemental Ca and N ratio interacted to affect leaf area. Pretransplant N ratio and supplemental Ca effects on seedling field performance, flowering, and yield were evaluated.

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## 177 ORAL SESSION (Abstr. 701-708) CROSS-COMMODITY GENETICS III

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701

### RESISTANCE OF WILD LETTUCE (*LACTUCA SALIGNA* L.) TO LETTUCE INFECTIOUS YELLOWS VIRUS

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Segregating generations from crosses of cultivated lettuce (*Lactuca sativa* L.) with wild lettuce (*L. saligna* L.) are affected by sterility and abnormal growth. Resistance to lettuce infectious yellows virus (LIYV) was, therefore, studied in crosses of previously reported LIYV-resistant (PI 261653) with LIYV-susceptible (PI 490999, PI 491000 and PI 491001) *L. saligna* accessions. Simple Mendelian ratios for resistance (measured as numbers of symptomless and symptomatic plants, and as number of symptomatic leaves per plant) to LIYV were not evident. PI 491001 had the fewest symptomatic plants and the fewest symptomatic leaves per plant. The potential value of *L. saligna* for development of LIYV-resistant cultivated lettuce will be discussed.

# GENETIC AND PHENOTYPIC DIVERSITY WITHIN SPECIES AND GROUPS OF AN IMPATIENS GERMPLASM COLLECTION

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Since the introduction of New Guinea impatiens in 1980 the genus *Impatiens* has remained the number one selling bedding plant in the U.S. However, basic information concerning the genus is lacking. This study was undertaken to estimate genetic and phenotypic diversity within species and groups of an *Impatiens* germplasm collection representing seven countries. It includes plants from the 1970 plant expedition co-sponsored by USDA-ARS and the Longwood Foundation (Kennett Square, PA); donations from the Royal Botanic Gardens (Kew, England); and ovule cultured interspecific hybrids created by Dr. Toru Arisumi (USDA, Beltsville, MD). The collection was grown in a common environment and characterized for 31 qualitative and quantitative morphological traits, and electrophoretically characterized for several enzymes using polyacrylamide gel electrophoresis. Evidence concerning putative interspecific hybrids and relationships among *Impatiens* groups based on morphological and electrophoretic characterization and diversity indices will be presented. Isozyme patterns lending support to hypotheses of center of origin, migration and evolution of *Impatiens* will also be discussed.

## 703

### EVALUATION OF SOMACLONAL VARIATION FOR RESISTANCE TO *MYROTHECIUM RORIDUM* IN REGENERANTS OF *CUCUMIS MELO* L. FROM COTYLEDONARY CALLUS

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*Cucumis melo* L. (muskmelon) is susceptible to *Myrothecium roridum* at all stages of growth with no known source of resistance. Screening of regenerants from long-term cotyledonary-derived callus cultures of muskmelon cv. Hales Best (tolerant), Iroquois (susceptible), and Perlita (intermediate) was carried out to determine if novel plants with increased levels of resistance could be obtained. A detached-leaf bioassay was used to screen greenhouse-grown regenerants and seedlings of the three cultivars. Resistance was determined by measuring necrotic lesion diameter and chlorotic plus necrotic lesion diameter. No change in the level of resistance to *M. roridum* has thus far been observed. Thus, screening for somaclonal variation may not be a viable approach to recover resistance in muskmelon to *M. roridum*.

## 704

### ASSESSMENT OF THE LIMITATIONS OF SOMATIC HYBRIDIZATION

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This study was designed to assess the general limitations of somatic hybridization as one of the key technologies for genetic manipulation in plants. The limits of somatic hybridization against different taxonomic backgrounds, intraspecific to interfamilial, were also assessed. Protoplast culture studies provided essential information relating to the species cultural and morphogenetic capacity. Several electrophoretic strategies for the recovery of somatic hybrid colonies/plants were developed and assessed using various combinations of protoplast sources and species in the genera *Petunia*, *Nicotiana*, *Salpiglossis* and *Chrysanthemum*. Morphological, cytological and biochemical analyses were performed to confirm the hybridity of plants or cell lines recovered following protoplast fusion (using 4-5 methods) and selection.

The somatic hybrid callus/plants were obtained at intraspecific to interfamilial levels by complementation to chlorophyll proficiency, together with media selection or complementation of nitrate reductase deficient mutants as follows: *P. hybrida* var. Monsanto (+) *P. hybrida* cv. Blue Lace (intraspecific), *P. hybrida* var. Monsanto (+) *P. inflata* cv. *P. parviflora* (interspecific), *P. parviflora* (+) *N. tabacum* (intergeneric), *S. sinuata* (+) *P. hybrida* var. Monsanto, *P. parviflora* (+) *N. tabacum* (intertribal), and *C. morifolium* (+) *S. sinuata*.

From this study, it appeared that there were no taxonomic limits to the production and proliferation of somatic hybrid cell lines. However, obtaining morphologically normal hybrid plants met with limited success as the taxonomic relationships became more distant. The regeneration capacity of somatic hybrids seemed to be controlled by both parental species. Somatic incompatibility mechanism was also shown to operate on chromosome elimination. Such chromosome elimination may well be advantageous in plant improvement.

## 705

### ABNORMAL SEGREGATION FOR MORPHOLOGICAL MARKER GENES IN PROGENIES OF TISSUE CULTURE-DERIVED REGENERANTS OF HETEROZYGOUS TOMATO HYBRIDS

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Heterozygous multiple marker genetic stocks were synthesized by crossing three multiple genetic marker stocks to a common inbred parent PU812.

The four parents and 3 F<sub>1</sub>'s were cultured to obtain regenerants from leaf discs. Fifty four regenerants were derived from 3 F<sub>1</sub>'s and 12 from the 4 parents. Among the regenerants, 16 plants were identified as tetraploid (24.2%); low fertility was usually associated with tetraploidy, however there were a few exceptions.

Selfed seeds, identified by cluster number, were harvested from sexual F<sub>1</sub>'s and R<sub>1</sub> plants for F<sub>2</sub> progeny tests for the known marker genes. While there were no abnormal segregations for marker genes in the sexual progenies, 13 of 46 progenies from tissue culture derived regenerants showed significant deviations from expected normal segregations for a number of markers. Two of the abnormal progenies were identified as tetraploids by root-tip examinations; segregation ratios fit duplex random chromatid segregation for gene *a* on chromosome 11 and random chromosome segregation for gene *c* on chromosome 6. The cams of abnormal segregations in other progenies remain unknown. Results suggest that unknown genetic events arising during tissue culture may distort segregations for marker genes in the subsequent sexual progeny of tissue culture regenerants.

## 706

### VARIATION FOR GENETIC RECOMBINATION AMONG TOMATO PLANTS REGENERATED FROM THREE TISSUE CULTURE SYSTEMS

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Genetic recombination rates of hybrid plants regenerated from three tissue culture systems were compared by backcrossing regenerated plants with mutant parents and comparing the observed crossover frequencies with those expected based on control plants raised from seed. Increased recombination rates and map distances were observed among plants from micropropagated shoot tips (4.5%-5.9%), cotyledon calli (3.7%-8.5%), and thin cell layers (2.8%-6.5%) between the *sunny* (*sy*) and *baby leaf syndrome* (*bls*) markers which flank the centromere on chromosome 3. Conversely, a decrease in map distance was observed between *bls* and the *solanifolia* (*sf*) locus which is more distal to the centromere on the same arm of chromosome 3 as *bls*. Increased map distance among plants regenerated from micropropagated shoot tips, cotyledon calli, and thin cell layers was also observed between *white virescence* (*wv*) and *anthocyanin reduced* (*are*) loci on chromosome 2.

## 707

### GENETIC VARIATION FOR ANTHOCYANIN AND CAROTENE PIGMENTATION OF CARROT ROOTS

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Genes for reduced carotene content (white, yellow, and pale orange) and for anthocyanin pigmentation were identified in *Daucus carota* PI 173687 and in progeny derived from crosses of this Plant Introduction with orange-rooted inbred lines. Monogenic inheritance for each of these root color variants was examined. Mixed cell cultures of callus derived from white and orange roots indicated autonomy of carotene gene expression in carrot cell cultures. Strategies for incorporation of carrot genes conditioning pigment content will depend upon gene combinations sought.

## 708

### THE GENETICS AND BREEDING FOR SALT TOLERANCE IN MELON, *CUCUMIS MELO*.

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The increasing salinity of both irrigated lands as well as irrigation water in many parts of the world have emphasized the importance of having appropriate breeding strategies for developing salt tolerant cultivars. In a program to breed for salt tolerance (high yield and good quality at 5,000 ppm salinity) in melons, several breeding strategies were tried. The only systems that succeeded was using combining abilities in a hybrid program. We found that salinity did not effect the number of fruit or fruit quality but only fruit weight. Fruit weight of hybrids grown in fresh water was controlled by dominant genes ( $h^2=0.09$ ) whereas the same hybrids grown under salinity had fruit weight control by additive genes ( $h^2=0.54$ ). Therefore, we were capable of breeding tolerant hybrids from non-tolerant parents.

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## 178 ORAL SESSION (Abstr. 709-714)

### HERBS: CULTURE/GROWTH AND DEVELOPMENT

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709

#### PRE- AND POSTHARVEST CHILL-HARDENING OF SWEET BASIL

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Postharvest shelf life of fresh sweet basil (*Ocimum basilicum* L.) at 5°C is only 3 to 4 d due to development of chilling injury symptoms. Plants chill-hardened at 10°C for 4 h daily (2 h at end of the light period and 2 h at the beginning of the dark period) for 2 d prior to harvest had 3 d extended shelf life at 5°C. Increasing the duration of preharvest chill-hardening did not further improve the shelf life. Plants were chill-hardened at 10°C for 4 h daily for one week at different periods during the day. Four-, 5- and 6-week-old basil were used in each of three consecutive runs. With the 4- and 5-week-old basil, chill-hardening at the beginning of the day extended average shelf life by 1 and 1.5 d at 5°C, respectively. Shelf life was either decreased or not affected by the other periods of preharvest chilling. Postharvest chill-hardening of packaged sweet basil for 1 d at 10°C before transfer to 5°C increased shelf life by 5 d. Postharvest chill-hardening has potential for reducing chilling injury of packaged sweet basil.

710

#### CONSTRUCTION AND DESIGN OF A PORTABLE STEAM DISTILLATION UNIT FOR ESSENTIAL OIL CROPS.

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A 500 liter (130 gallon) stainless steel steam distillation unit has been built to extract volatile essential oils from aromatic plants. A 1.5 m × 0.75 m dia. steam vessel (hydrostatically tested @ 125 psi) serves as the distillation tank. Low pressure or high pressure steam is supplied by a diesel fuel fired boiler of 10 horsepower. The steam vessel can hold peppermint from plots of 25 m<sup>2</sup> and extract approximately 100 ml of essential oil per distillation. The size of the tub was designed to provide oil in sufficient quantity for industrial evacuation or for pesticide residue analysis. Following the distillation, the vessel can be disconnected from the cold-water condenser and rotated on swivels to a horizontal position, permitting easy removal and re-filling of plant material. The entire extraction unit (vessel, condenser, boiler and oil collector) is suitable for mounting upon a trailer, making it transportable to commercial farms or research stations. The extraction of peppermint and spearmint oils using this new system will be presented.

711

#### TRANSFORMATION OF ORANGEMINT (MENTHA CITRATA, EHRH) WITH AGROBACTERIUM TUMEFACIENS

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Orangemint leaf disks were infected with three strains of *Agrobacterium tumefaciens*: A281, a hyper-virulent strain containing plasmid pTiBo542; C58, a strain containing nopaline Ti plasmid pTiC58; and A136, a derivative of C58 lacking the nopaline Ti plasmid. After a 24 or 48 hr cocultivation, leaf disks were placed on a medium containing MS salts and vitamins, 2% sucrose, and 200 µg ml<sup>-1</sup> cefotaxime. Callus formed only on those leaf disks infected with A281. Five callus lines (R-12, -71, -73, -81, -83) were putatively transformed based on succinopine production. Definitive transformations were confirmed via DNA slot blot analysis. All callus lines assayed (R-11, -12, -41, -73, -83) hybridized to a 7.7 KB fragment from the T-DNA region.

712

#### INFLUENCE OF PLANTING DATE AND HARVEST TIME ON ARTEMISIA ANNUA L.

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*Artemisia annua* L. is an aromatic and medicinal plant of importance for its volatile essential oils, and the non-volatile artemisinin used in the treatment of malaria. To determine the optimum time of planting for growth and the accumulation of essential oils, seedlings of *A. annua* (Purdue accession 012) were transplanted into the field in Central Indiana in a RBD with 3 replications on April 25, May 24, June

24, and July 25, 1988. Plant samples were harvested every 2 weeks until first frost.

The April and May transplanting dates produced the tallest plants (>180 cm) while the May transplants accumulated the greatest fresh and dry weights. The average increase in plant height was greatest for the June 24 planting date at 9.8 cm per week. Regardless of planting date, all plants began to flower by early August and growth rate began to decrease by late August. Accumulation of essential oil (as rel. % dry wt.) was similar for all planting dates. Essential oil increased until floral initiation, then decreased for 2 weeks after which there was a rapid increase in oil accumulation. Maximum oil accumulation from all planting dates was reached on Sept. 28 after which growth continued to increase.

713

#### CHANGES IN THE ESSENTIAL OILS AND TRICHOME DENSITY OF OCIMUM BASILICUM L.

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Essential oil content of *Ocimum basilicum*, cv. sweet basil, increases with plant maturity. The increase in essential oil content may correspond to the formation of glandular trichomes during leaf expansion. Greenhouse grown plants were harvested every 2 weeks. Leaves were grouped according to size, examined with a stereo microscope, and trichome densities compared. Results indicate that trichome formation continues throughout leaf expansion. In young basil plants, leaves ranged in size from 2-30 cm<sup>2</sup>. Highest density (416 trichomes/cm<sup>2</sup>) occurred in leaves 2-6 cm<sup>2</sup>. Prior to open bloom, leaves ranged in size from 2-49 cm<sup>2</sup>. Highest density occurred in leaves 18-24 cm<sup>2</sup>. In flowering plants leaves ranged in size from 2-34 cm<sup>2</sup>, yet there was NSD in trichome density in leaves of different sizes. Analysis of the entire leaf surface of plants at each harvest showed the greatest density of trichomes in plants at full bloom (280 trichomes/cm<sup>2</sup>). All leaves have visible glandular trichomes. These glandular trichomes are most likely formed both prior to and during leaf expansion.

714

#### EFFECTS OF N FERTILITY, PLANT DENSITY AND CULTIVAR ON YIELD OF DILL

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Two experiments were conducted in 1988 and 1990 to determine the effects of planting density, N fertilizer rate, and cultivar on fresh yield of dill. A split plot design was used in the first experiment in which planting density (one versus two rows per bed) was the main plot treatment and N rate (0, 56, 112 kg/ha) was the subplot treatment. A European cultivar, 'Crown,' was used in the first experiment in 1988 while 'Long Island Mammoth' was planted in 1990. N was applied in split applications while both K<sub>2</sub>O and P<sub>2</sub>O<sub>5</sub> were preplant incorporated at the rate of 134 kg/ha. Planting was done on bedded rows approximately 66 cm wide and 15 cm high. N fertilizer application did not affect yield in 1988. Leaf, stem, flower, and total yields were greater for the high density planting. The second experiment evaluated yield of four cultivars ('Tetra,' 'Bouquet,' 'Long Island Mammoth,' and 'Crown') using a randomized complete block design. 'Long Island Mammoth' and 'Tetra' produced greater leaf and total fresh weight while 'Long Island Mammoth' and 'Bouquet' produced greater flower fresh weight.

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## 179 ORAL SESSION (Abstr. 715-722)

### CROSS-COMMODITY PHOTOSYNTHESIS

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715

#### PHOTOSYNTHESIS, RESPIRATION, AND CARBON COST OF DEVELOPING RABBITEYE BLUEBERRY FRUIT

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Carbon exchange and content of blueberry (*Vaccinium ashei*) fruit were measured from anthesis through fruit ripening in order to determine the amount of imported carbon required for fruit development. Net photosynthesis occurred in blueberry

fruit from petal fall through color break. During this time, gross photosynthesis of fruit decreased from 30.1  $\mu\text{mol CO}_2\text{g}^{-1}\text{fw}^{-1}\text{hr}^{-1}$  to 4.8  $\mu\text{mol CO}_2\text{g}^{-1}\text{fw}^{-1}\text{hr}^{-1}$ , and dark respiration decreased from 14.3  $\mu\text{mol CO}_2\text{g}^{-1}\text{fw}^{-1}\text{hr}^{-1}$  to 4.6  $\mu\text{mol CO}_2\text{g}^{-1}\text{fw}^{-1}\text{hr}^{-1}$ . After color break, the photosynthetic rate fell to zero, and the respiration rate increased to 8.0  $\mu\text{mol CO}_2\text{g}^{-1}\text{fw}^{-1}\text{hr}^{-1}$ , before decreasing. Preliminary data suggest that fruit photosynthesis contributes 11% of the total carbon required (dry weight gain + respiratory loss) during fruit development however, it supplies 50% of the total carbon required during the first 5 days after petal fall. This contribution of carbon from fruit photosynthesis may be critical in initial fruit development since the current season's vegetative growth is not yet providing carbohydrates.

716

#### EFFECTS OF FRUIT AND GIRDLING ON GAS EXCHANGE, SPECIFIC LEAF WEIGHT, WATER POTENTIAL, AND CARBOHYDRATE CONTENT OF APPLE LEAVES

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Fruiting spurs ('Red Prince Delicious') (RD) and shoots ('Sundale Spur Golden Delicious') (CD) with three leaf:fruit ratios and comparable nonfruiting spurs and shoots were girdled on 7 September 1988. An interaction between fruiting status and time existed for most parameters measured on both cultivars while there was no effect of leaf:fruit ratio. At 1 day after treatment (DAT) few differences existed due to fruiting status on either cultivar. At 8 DAT with RD and at 4 and 8 DAT with GD, Pn, transpiration (Tr), leaf water potential ( $\psi$ ), and nonreducing sugars were greater on fruiting than nonfruiting spurs and shoots while leaf resistance ( $R_L$ ), SLW, and starch were lower on fruiting spurs. In nonfruiting spurs and shoots Pn, Tr, and  $\psi$  tended to decrease while  $R_L$  and SLW increased with time whereas in fruiting spurs and shoots most parameters remained constant. Total nonstructural carbohydrates, reducing sugars, and starch were greater in nonfruiting than fruiting spurs and shoots.

717

#### VARIABILITY IN FOURTH DERIVATIVE LEAF SPECTROSCOPY OF FRAGARIA SPP. AND ITS RELATIONSHIP TO PHOTOSYNTHESIS

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Accumulated attendance and fourth-derivative spectra were measured using intact leaf samples at room temperature for 80 genotypes of four *Fragaria* species. Attendance peak wavelength and amplitude data of all samples was pooled and yielded 25 common bands for *Fragaria*. Of these, 14 chlorophyll bands and two phototransformed bands were consistent with French's (1972) model.

Peak wavelengths and amplitudes which represent major bands in *F. chiloensis* and *F. × ananassa* spectra were also determined separately. While peak wavelengths of the two species were identical, variation was noted in peak amplitude. The signals of the bands at Cb640, Cb649, Ca670, Ca673, Ca675-676, Ca684 and Ca693 in *F. chiloensis* were significantly stronger than those in *F. × ananassa*. Ca677 and Ca695 were stronger in *F. × ananassa*.

The greatest difference among *Fragaria* species was found in the amplitude of Ca693. The amplitude of this peak was greatest in *F. chiloensis* (0.0025) and smallest in *F. virginiana* (-0.0005). The cultivated hybrid of these two species, *F. × ananassa*, was intermediate (0.0008). Preliminary evidence suggests that certain genotype-specific spectral characteristics may relate directly to observed differences in photosynthetic biology among these species.

718

#### PHOTOSYNTHESIS AND RUBISCO IN STRAWBERRY SPECIES

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$\text{CO}_2$  assimilation (20-25%) and carboxylation efficiency (30-35%) was greater ( $P < 0.01$ ) in *Fragaria chiloensis*, clone RCP37 than *F. ananassa* cv. 'Midway'. Both leaf thickness ( $P < 0.05$ ) and internal mesophyll cell surface area ( $P < 0.01$ ) was greater in RCP37 than 'Midway'. No differences in Rubisco specific activity were observed between the 2 species, whereas Rubisco amount was 40% greater ( $P < 0.01$ ) and leaf nitrogen per area was 30-35% greater in RCP37 compared to 'Midway'. Potential for selection of clones with high photosynthesis by screening for soluble protein will be discussed.

719

#### EFFECT OF TWO-SPOTTED SPIDER MITE FEEDING ON GAS EXCHANGE AND CHLOROPHYLL CHARACTERISTICS OF RED RASPBERRY LEAVES

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At two-week intervals from 17 June to 15 July, three groups of 'Meeker' red raspberry plants were infested with two-spotted spider mites (*Tetranychus urticae*) in a greenhouse. While populations on individual plants were allowed to develop freely, control plants were kept free of mites with a chemical miticide. Gas exchange measurements were made on 27 July prior to visible mite damage, and on 7 October after injury was apparent. The relationships between mite populations and leaf gas exchange and chlorophyll characteristics were described using a logarithmic function.

Physiological responses to mite feeding were observed prior to visible leaf injury. On both dates,  $\text{CO}_2$  assimilation rates decreased ( $p \leq 0.001$ ) with increasing mite numbers per leaflet. On 27 June, a significant relationship ( $R^2 = 0.61^{***}$ ) was found between mite number and mesophyll conductance ( $g_m$ ). On 7 October, significant relationships ( $p \leq 0.001$ ) were also observed with  $g_m$ , stomatal conductance ( $g_s$ ), and transpiration (E). Total chlorophyll content of leaves decreased with increasing mite populations, but chlorophyll a/b ratio and dry weight per leaf unit area were unchanged.

720

#### PHOTOSYNTHETIC INHIBITION IN STRAWBERRY GROWN UNDER TWICE AMBIENT $\text{CO}_2$

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'Midway' and 'Raritan' strawberry cultivars were grown for six weeks under ambient (350) or twice ambient (700  $\mu\text{mol mol}^{-1}$ )  $\text{CO}_2$ . Photosynthetic inhibition (40-50%) was observed in both cultivars as indicated by reductions ( $P < 0.001$ ) in  $\text{CO}_2$  assimilation, carboxylation efficiency, stomatal conductance, and apparent quantum yield. Growth under high  $\text{CO}_2$  did not affect Rubisco activity in either cultivar, whereas Rubisco activation state (%) was reduced (72.9 to 67.6) in 'Midway' and increased (70.8 to 83.3) in 'Raritan' compared to ambient  $\text{CO}_2$  grown plants. Soluble and Rubisco protein decreased 10-15% in 'Midway' and 40-45% in 'Raritan' when grown under high  $\text{CO}_2$ . Thus, 'Raritan' reduced the amount of protein partitioned into photosynthetic enzymes under conditions of photosynthetic inhibition, whereas 'Midway' experiences Rubisco deactivation. The reduction in Rubisco protein appears to be under the regulation of chloroplast genes.

721

#### STRAWBERRY LEAF PHOTOSYNTHESIS ACCLIMATION TO TEMPERATURE

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The commercial strawberry *Fragaria × ananassa* and several clones of *F. chiloensis* and *F. virginiana* were pre-conditioned in growth chambers under the following conditions: 500  $\mu\text{mol m}^{-2}\text{s}^{-1}$  PAR and 20° day, 10° night or 30° day and 20° night. After at least 3 weeks of preconditioning at the two different temperature regimes, leaf photosynthetic rate (A) was determined for temperatures ranging from 10 to 35° in 2-3° increments with an open gas exchange system under laboratory conditions. The objective was to determine if *F. virginiana* and *F. × ananassa* can photosynthesize at higher temperatures than *F. chiloensis*, and if any of these would acclimate to higher temperatures. *F. chiloensis* did not acclimate to higher temperatures, and had maximum A between 16 and 20°. *F. virginiana* did acclimate to higher temperatures, with maximum A for the low temp treatment between 18 and 24°, and for the high temp treatment between 24 and 30°. The commercial cultivars of 'Earliglow' and 'Redchief' acclimated to higher temperature and responded similar to *F. virginiana*.

722

#### GAS EXCHANGE AND FERN WATER POTENTIALS OF WATER-STRESSED ASPARAGUS

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Asparagus is considered a relatively drought tolerant plant, but few studies are available on the gas exchange response to soil moisture stress. Seedlings were grown in the greenhouse for six months before initiation of the water stress treatments. Soils were allowed to dry to

matric potentials of -0.05, -0.3 and -0.5 MPa before rewetting to pot capacity. Gas exchange and fern water potentials were measured diurnally on asparagus plants when soil matric potentials reached their minima. Decreasing soil matric potentials decreased net carbon dioxide assimilation, stomatal conductance and fern water potential. Assimilation rates (6 am) were between 3 and 5  $\mu\text{mol m}^{-2} \text{s}^{-1}$  for all soil moisture treatments. Carbon assimilation rates of 10, 8, and 7  $\mu\text{mol m}^{-2} \text{s}^{-1}$  were recorded at 10 am for the -0.05, -0.3 and -0.5 MPa soil matric potentials, respectively. Assimilation rates decreased sharply over the remainder of the day. The diurnal pattern for conductance were similar to the assimilation rates. Fern water potentials were greater in the -0.05 MPa than in the -0.5 MPa treatment for all measurement periods with an intermediate response for soil matric potentials of -0.3 MPa. Fern water potentials were highest at 6 am (-0.2 to -0.6 MPa) before declining to their minima (-1.5 to -1.8 MPa) at 10 am. Water potentials remained at these low levels throughout the day before recovering slightly at 6 pm.

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## 185 ORAL SESSION (Abstr. 723-730)

### FRUIT CROPS: GROWTH SUBSTANCES

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723

#### UTILIZATION OF POSTHARVEST GIBBERELLIC ACID SPRAYS TO REDUCE HAND THINNING IN 'PATTERSON' APRICOT

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Heavy fruit set of apricot (*Prunus armeniaca*) cultivars grown in California often require hand thinning to insure that adequate fruit size is obtained. Alternatives to costly hand thinning would be welcome. GA treatments made during flower bud initiation/differentiation have been previously shown to inhibit the development of floral and vegetative buds in a number of different tree fruit species. The effects of post-harvest limb and whole tree aqueous gibberellic acid (GA) sprays on flower and fruit production were investigated over a 3 year period in 'Patterson' apricot. Limb treatments indicated the potential for utilizing postharvest GA sprays to reduce the number of flowers produced in the following season. Harvest fruit size (June 1989) was increased by a 100 mg-liter<sup>-1</sup> GA whole tree spray applied 7 July 1988 when compared to non-thinned and hand thinned trees. Yield per tree was reduced by that GA spray, but not enough to show statistical differences. No abnormal tree growth responses have been observed in GA-sprayed trees to date. These results and those from the 1989 and 1990 growing seasons will be presented in effort to identify a role for whole tree postharvest GA sprays in a chemical thinning program suitable for commercial apricots.

724

#### GA<sub>3</sub> SPRAYS ALTER THE FATE OF LATERAL MERISTEMS OF 'REDKIST' PEACH.

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GA<sub>3</sub> sprays were applied to 10 primary scaffold limb replications with a handgun at three concentrations (25, 50, 100 mg/l), from May to September 1989. Flower bud thinning with GA<sub>3</sub> applied in the year prior to bloom was examined for its effect on the developmental fate of lateral meristems. Limbs treated in late May had, on average, 45% more flower buds survive near-critical winter temperatures than did controls. During the period of greatest sensitivity to Flower Bud Density (FBD) reduction, GA<sub>3</sub> treated limbs had vegetative bud densities (VBD) higher than control (on average 45% greater at 100 mg/l). On 9 June 100 mg/l reduced FBD by 78% compared to control and increased VBD by 57%, while on 6 July the same concentration reduced FBD by 94% but VBD was increased by only 32%. These results appear to support the hypothesis that GA<sub>3</sub> induced FBD reduction has more than one mode of action.

725

#### EFFECT OF GA<sub>3</sub> ON THE TIME OF MATURITY, FIRMNESS, COLOR AND SIZE OF PEACH FRUIT.

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GA<sub>3</sub> sprays (50, 65, 100 mg/L) were applied to six single tree replications of mature 'Redhaven' and 'Cresthaven' trees on 23 June 1989 to measure their effect on fruit maturity and

the relationship among its indices. There was little effect of GA<sub>3</sub> on fruit diameter except on the final harvest when the treated trees had 6% larger fruits. Seventy-two percent of the total yield of 'Redhaven' control trees was mature at the first picking while only 30% of total yield from treated trees was ready on the same date. GA<sub>3</sub> had a similar effect on fruit maturation on 'Cresthaven'. Fruit on treated 'Redhaven' trees were on average 1.3 kg firmer than control. Furthermore, GA<sub>3</sub> increased the firmness over control on the shaded and sunny side and the suture of the fruit and no interaction between the location of pressure test and GA<sub>3</sub> treatments was observed. There was a slight reduction in yellow ground color of GA<sub>3</sub> treated fruits. The effect of GA<sub>3</sub> on the relationship between individual fruit color and firmness will be examined. The effects of 1990 GA<sub>3</sub> sprays on peach maturity and quality will also be presented.

726

#### EFFECT OF SURFACTANTS ON UPTAKE OF GIBBERELLIN A<sub>3</sub> BY SOUR CHERRY LEAVES

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Gibberellin A<sub>3</sub> (GA<sub>3</sub>) applied to virus-infected sour cherry (*Prunus cerasus* L., 'Montmorency') trees inhibits flower initiation and promotes spur formation. However, response to a given dose may vary. Differential foliar absorption has been suggested as a major source of this variation. Therefore, we studied if surfactants would reduce variation in GA absorption. Uptake through the abaxial surface exceeded that through the adaxial surface by about one order of magnitude (adaxial surface 1.1 vs 7.8% in 1988, 0.7 vs 16.6% in 1989). GA uptake was markedly affected by surfactants. Over a 24-hr uptake period, Activator 90 and Ortho X-77 were most effective (abaxial surface 38.3 and 37.4% in 1989), whereas Regulaid did not affect GA uptake. L-77 significantly depressed absorption (abaxial surface 9.1% in 1989). In addition to the level of uptake, surfactants also changed GA absorption kinetics. Penetration increased linearly over a 96-hr time period when Regulaid was included. However, with Ortho X-77, uptake was rapid initially but levelled off within 96 hr. These findings will be discussed in relation to biological response data obtained in the field experiments.

727

#### ETHEPHON REDUCES PEACH FLOWER BUD REHARDENING

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Peach (*Prunus persica* (L.) Batsch cv Jerseydawn and Jerseyglo) flower bud hardness was studied using exotherm analysis following application of ethephon ((2-chloroethyl) phosphoric acid, 0.7mM) in October. Rehardening varied with temperature (7 or 21°C), cultivar, ethephon treatment, and sampling date. Buds were more susceptible to injury in March compared to January or February. Buds rehardened more rapidly at 21°C than at 7°C. 'Jerseyglo' rehardened more rapidly than 'Jerseydawn'. Untreated buds were less hardy and also rehardened more rapidly than treated buds. Ethephon enhanced flower bud hardness by (1) decreasing the mean low temperature exotherm of pistils, (2) increasing the number of buds which supercooled after rehardening, and (3) it decreased the rate of rehardening.

728

#### THIDIAZURON EFFECTS ON GROWTH INITIATION AND EXPRESSION IN MANGO (*MANGIFERA INDICA* L.)

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Thidiazuron (TDZ; N-phenyl-N-1,2,3-thiadiazol-5-ylurea) stimulates axillary bud break in some horticultural crops. We are exploring its ability to initiate bud growth in mango trees in order to manipulate vegetative and reproductive shoot initiation. Axillary buds on defoliated, decapitated shoots were treated in late October, 1989 (about two months before normal floral initiation), with 0, 125, or 1000 ppm TDZ. Although timing or percent of bud-break was unaffected by TDZ, the compound influenced growth expres-

sion. TDZ (125 ppm) produced morphologically typical panicles (mixed or purely floral), while at 1000 ppm purely floral panicles were produced which were abnormally compact (similar to panicles affected by mango malformation). Non-treated buds produced only vegetative shoots. Sprays of TDZ (25 to 200 ppm) on developing panicles produced morphological anomalies in panicles such as thickening of the central axis and secondary branches, increase in flower size, and sprouting of the most basal buds on the central axis. Effect during the vegetative flushing period will be discussed.

729

#### THE EFFECT OF CHLORPYRIFOS ON FRUIT DEVELOPMENT IN GRAPEFRUIT, *CITRUS PARADISI* MACFAYDEN.

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Deformations consisting of longitudinal ridges in the rind of Citrus fruits have recently been found in Southern California Citrus groves. Here, we report the correlation between ridge formation and applications of chlorpyrifos (Lorsban, Dow Chemical Company, Midland, MI) during the feather-growth stage of bud break. All chlorpyrifos formulations resulted in significant ridging. Addition of agricultural oil and 2,4-D (2,4-dichlorophenoxyacetic acid (2,4-D) to chlorpyrifos resulted in the greatest ridging damage and widened the window of susceptibility by 2 weeks in 1988. In 1989, no significant difference was seen between treatments of chlorpyrifos, although all were significantly greater than the control. The susceptible stages of bud growth are described, as are the non-susceptible stages which precede and follow it. Floral buds in which carpels are initiating are susceptible to fruit ridging upon application with chlorpyrifos. These ridges are the result of an increase in cell size of the flavedo tissue which may be the result of a polyploid chimera.

730

#### BERRY RESPONSE OF MUSCADINE GRAPES TO ORGANIC CHEMICAL APPLICATION DURING MATURATION AND RIPENING Fouad M. Basiouny\*, Plant and Soil Sciences, Tuskegee University, Tuskegee, AL 36088

Malonic acid, 3(3,4 dichlorophenyl)-1,1 dimethylurea, Gibberellic acid, and 2,4,5-trichlorophenoxypropionic acid were applied to muscadine grapes (*Vitis rotundifolia* Michx) during maturation and ripening. Total soluble solids, sugars, anthocyanin contents, and other fruit qualities were affected. 3(3,4 dichlorophenyl)-1,1 dimethylurea (diuron) seemed to induce better and different effects than the other chemicals.

## 186 ORAL SESSION (Abstr. 731-738) CROSS-COMMODITY GENETICS IV

731

#### SPARKLEBERRY × BLUEBERRY CROSSES

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Diploid blueberry (*Vaccinium* section *Cyanococcus*) was pollinated in a greenhouse in 1981 with pollen from sparkleberry (*V. arboreum*, Section *Batodendron*). *Cyanococcus* parents included *V. darrowi*, diploid *V. corymbosum*, and various intra-sectional diploid hybrids. Forty one vigorous seedlings showing characteristics of both sections were selected from a field nursery when 2 1/2 years old. Some of these plants flowered heavily in subsequent years, and several were more than 3 m tall by 1990. Although the F<sub>1</sub> hybrids had very low fertility, some open-pollinated progeny were obtained. Some of these were vigorous, fruitful when open-pollinated in the field, and intermediate between *V. arboreum* and *Cyanococcus* in many features. Six of the best progeny from open-pollination of the F<sub>1</sub>'s were used in greenhouse crosses. Some branches were self-pollinated and some were pollinated with pollen from tetraploid *V. corymbosum*-based cultivars. Two of the 3 selfed plants had a high percent fruit set (277 fruit from 441 flowers). Four of the six plants pollinated with pollen from tetraploid *V. corymbosum* cultivars had high percent fruit set (452 fruit from 793 flowers). Flowers of the open-pollinated progeny of the F<sub>1</sub> hybrids were much larger than those of the F<sub>1</sub>'s. This, along with the fruitfulness after 4x pollination, suggests that at least some of the open-pollinated progeny are tetraploid. These hybrids give hope that sparkleberry genes can be used to improve highbush cultivars.

732

#### LEAF SPOT COLOR AND VENATION INHERITANCE AND PETIOLE STRENGTH VARIATION IN CALADIUM

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The mode of leaf spot color, venation color and pattern inheritance and differences in the apparent strength of leaf petioles were investigated. Progeny from self pollinations of *Caladium bicolor* cv. Painter's Palette and two commercial cultivars ('Florida Cardinal' and 'Aaron') were utilized in a pedigree and back cross breeding program to delineate and prove a proposed model for the mechanisms controlling spot and vein color inheritance as well as the inheritance of venation patterns. Differences in the apparent strength of leaf petioles in *Caladium* were observed in the field. Anatomical and mechanical analysis using a Kramer Shear Cell, showed significant differences among 12 experimental lines. The relative strength of the petioles were correlated to petiole pigmentation, with darker colored petioles being stronger and less prone to bending than lighter colored petioles.

733

#### CHARACTERIZATION OF A MALE-STERILE SYSTEM WITH A CLOSELY LINKED SEEDLING MARKER TO FACILITATE F<sub>1</sub> HYBRID TOMATO SEED PRODUCTION

Edward C. Tigchelaar, Department of Horticulture, Purdue University, West Lafayette, IN 47907

The coupling phase linkages have been synthesized between the gene *aw* (without anthocyanin) and the male sterile gene *ms15* (and its alleles *ms26*, *ms47*, and an Israeli source of male sterility). Less than 2 map units separate *aw* and *ms15* on chromosome 2, providing a convenient seedling marker gene to rapidly identify male sterility for both inbred development and hybrid seed production. The seedling marker also provides a convenient marker to rapidly assess hybrid seed purity. Unique features of each of the alleles involved in male sterility and their use in inbred and hybrid development will be described.

734

#### FUNCTIONAL MALE STERILITY IN EGGPLANT: INHERITANCE AND LINKAGE TO THE PURPLE FRUIT COLOR GENE

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The functional male sterile (*fms*) eggplant (*Solanum melongena* L.) germplasm UGA 1-MS was crossed with two cultivars, 'UGA 18 White' and 'Florida Market' with normal anthers to derive F<sub>1</sub>, F<sub>2</sub>, and BC populations. Functional male sterility (*fms*) was governed by a single recessive allele. The gene symbol *fms* is proposed for this male sterile characteristic. The functional male sterility gene was linked to purple fruit color at the X/x locus. Our observations also revealed that the purple or violet color were not only on the fruit peel, but also on the anthers and leaf buds if the eggplant fruit was purple or violet. In the transmission of parents and progenies of the cross of UGA 1-MS × 'UGA 18 White', the purple line on the anther and leaf bud purple color were tightly associated with fruit purple color. Thus, it is assumed that the allele X controls not only purple fruit, but also the expression of the purple line on the anther and purple leaf bud.

736

#### A LONG-DAY GENE FOR FLOWERING TIME IN *LACTUCA*

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Genes for flowering time appear to be relatively common in lettuce and other *Lactuca* species. These include previously described major genes *Ef-1* and *Ef-2*, other genes of discrete effect and genes acting in a quantitative manner. Our goals in studying the flowering time phenomenon are: 1) describe the inheritance of the traits, 2) establish their relationship to each other, and 3) elucidate their evolutionary significance.

The PI 175735 (*L. serriola*) is an accession with narrow leaves, spines and anthocyanin. Its flowering time is daylength related; it is early flowering under long days and late flowering under short days. It was crossed with the late flowering line C-2-1-1, which is homozygous for both late alleles in the *Ef* system. The F<sub>1</sub> is late under short days and early under long days. The F<sub>2</sub> population and F<sub>3</sub> families were grown under long day conditions in the greenhouse. Segregation in the F<sub>2</sub> was 3 early: 1 late. Among F<sub>3</sub> families from early plants, segregation was 1 homozygous early: 2 segregating. Within segregating families, the ratio was again 3:1. The evidence suggests a single gene with earliness dominant.



CHARACTERIZATION, INHERITANCE AND PRACTICAL APPLICATION OF FUSED-VEIN TRAIT IN SQUASH, CUCURBITA PEPO L.  
J. Brent Loy, R. Bruce Carle\*, Mark G. Hutton<sup>1</sup>, Dept of Plant Biology, University of New Hampshire, Durham, NH 03824 and <sup>1</sup>Peto Seed Co., Bridgeton, NJ 08302-8723.

A new leaf mutant, fused-vein, is described in *Cucurbita pepo* L. for use as a plant gene marker. Morphologically, the fused-vein trait is characterized by a partial fusion of the lateral leaf veins to the main central vein. Fusion begins at the distal point of the petiole and extends for 5 to 10 cm into the leaf blade, thereby delaying branching of the leaf veins and causing the dorsal leaf surface to appear puckered. The trait is expressed beginning at the fourth to sixth leaf stage and throughout vegetative growth. Preliminary inheritance data suggests a two gene, double recessive model. Data on segregation of the fused-vein trait in reciprocal  $F_1$  and backcross progenies will be obtained during the summer of 1990. This trait has been incorporated into hull-less seeded lines for use as a marker to identify rogue genotypes. Comparison of  $F_1$  sister lines with and without the fused-vein trait indicated that the trait does not affect fruit or seed yields.

738

#### INHERITANCE OF ZINGIBERENE IN LYCOPERSICON

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Zingiberene, a sesquiterpene, was detected in the foliage extract of *L. hirsutum* f. *hirsutum* Humb. and Bonpl. (hir), and confirmed by GC-MS. Zingiberene does not exist in *L. hirsutum* f. *glabratum* C. H. Mull (gla), which instead contains 2-tridecanone. 2-Tridecanone confers resistance to gla against Colorado Potato Beetle. The Presence of Zingiberene is associated with resistance against Colorado Potato Beetle in hir, which does not contain 2-tridecanone. The gene that conditions zingiberene acts differently in two different genetic backgrounds. In gla  $\times$  hir this gene acts as a single recessive gene, while in *L. esculentum*  $\times$  hir it acts as a single dominant gene. This situation, which has been studied in  $F_2$  and backcross populations of crosses in both directions are examined and discussed.

## 187 ORAL SESSION (Abstr. 739-746) FRUIT CROPS: GROWTH AND DEVELOPMENT III

739

#### TRAINING PERMANENT AND TEMPORARY TREES

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High orchard establishment costs require greater production early in an orchard's life. Our goal was to develop temporary trees at the least cost with the best early production. Health and longevity of permanent trees is essential. Six pruning treatments were evaluated in five-tree plots using a randomized complete block design. Each treatment was replicated four times on the 'Butte' and 'Mission' almond cultivars. After six years, temporary trees receiving the least pruning had the highest yields. Permanent trees had lower yields since more pruning was done in the second through fourth dormant seasons to develop branch framework for the long term. 'Butte' and 'Mission' responses to treatment varied due to varietal growth habits. Effects on tree development and the need for later corrective pruning were noted. After four harvests, yields were greater with less pruning.

740

#### CHARACTERISTICS OF OLIVE FLOWER AND FRUIT ABSCISSION: SOURCES OF VARIATION IN A NATURAL POPULATION.

George C. Martin\*, Chic Nishijima and Jack D. Early Jr. Department of Pomology, University of California, Davis, CA 95616

Olive fruit persistence is a crucial component of yield and an important factor in estimating alternate bearing potential.

Unfortunately, measurement of fruit persistence exhibit considerable variation, with coefficients of variation greater than 100. Such a high degree of variation makes field studies on questions regarding flowering and fruiting unmanageable due to the large number of experimental units necessary. To determine the source of this variation and how it might be reduced, comparisons of flower and fruit number per node were made within branches and trees over the course of two seasons. Results show that while the largest population of flowers are most distal on the branch, the central portion of the branch contains the majority of the final fruit population and has the lowest coefficient of variation. Furthermore, variation in the number of flowers and fruits is greater between branches than between nodes or trees. The implications of these data on experimental design are discussed and a design is proposed for reducing variation and labor needs.

741

#### COMPARISON OF YEARLY VARIATION IN FLORIDA CITRUS POUNDS SOLIDS PRODUCTION TO SEASONAL CLIMATIC VARIATION

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In Florida, pounds soluble solids per box (% soluble solids  $\times$  % juice  $\times$  weight) can be 60% higher in some years compared to the lowest years. Pounds solids, soluble solids and juice content data were obtained for the different citrus growing districts in Florida for a 20-year period from the USDA and Florida Agricultural Statistics Service. Weather data for each district was obtained from US National Weather Service records. Total rainfall and average daily temperature were calculated for 2-month periods from prior to the normal bloom period until harvest. Juice data was regressed against weather data and the previous years pounds solids using a stepwise multiple regression program. R values for early oranges, 'Marsh Seedless' grapefruit and 'Valencia' were 0.48, 0.48 and 0.72, respectively. Prebloom and bloom rainfall and temperatures were frequently positively correlated, while summer rainfall often was a negatively correlated independent variable to final pounds solids. Additional data and physiological implications will be discussed.

742

#### BRANCH AUTONOMY AND BLANKING IN PISTACHIO

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An average of >20% seedless (blank) fruit are produced annually in *Pistacia vera* cv. Kerman. The degree of blank production was reportedly not related to individual tree yields and, therefore, was not thought to be resource limited (Crane, J.C., 1973. HortSci. 8:388-390). In two crop years, we studied the variability in percentage blanking among individual shoots characterized by widely varying leaf area to fruit (L/F) ratios. L/F ratios were related inversely to the percentage of blank fruit produced. Thus, individual branches behaved somewhat autonomously with respect to blanking. Our data are consistent with the view that embryo development was resource-limited. Although 'Kerman' exhibits the potentiality for parthenocarpic fruit set, the hissed distribution of seedless fruit within the tree presumably indicates that blanking is an example of stenospermocarp. Blanking does not result primarily from inadequate pollination under typical field conditions.

743

#### XENIA AND METAXENIA: DEFINITIONS AND OTHER BOUNDARIES

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Xenia and metaxenia are phenomena dealing with the effects that pollen from different sources have on certain characteristics exhibited by seeds and fruits in a variety of species. A review of dictionaries, textbooks, and the scientific literature reveals that there is widespread confusion with regard to the nature of these phenomena and how they are to be distinguished. This discussion will attempt to clarify the boundary between these related phenomena by examining both the origins of the terms and our present understanding of the metabolism and anatomy involved. From this perspective, we contend that xenia applies to pollen effects as exhibited in the synergous parts of ovules, that is, the embryo and endosperm only. Metaxenia applies to such effects found in any structure beyond the embryo and endosperm, this is, in tissues which derive wholly from mother plant material. Metaxenia then encompasses effects found in seed parts such as the nucellus and testa as well as those found in carpels and accessory tissue.

# MANIPULATION OF VEGETATIVE, GENERATIVE, AND MIXED SHOOT TYPES IN CITRUS

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Fruit set in some species of citrus is greater on mixed shoots (leafy inflorescences) than on generative shoots (leafless inflorescences). Combination treatments involving water stress, cool winter night temperatures, and branch pruning were used to manipulate the number of shoots and ratios of the three shoot types in containerized 'Tahiti' lime (*Citrus latifolia* Tan.) plants. Plants were water stressed in a greenhouse for five weeks, pruned after rewatering, transferred to the open environment, and observed three weeks later. Appropriate control plants were carried along with treated ones. Combination treatments of all three variables increased the number and ratio of mixed shoots four fold over the non-stressed, non-pruned controls. More shoots formed on non-pruned, water stressed plants than on controls. Both formed predominantly generative shoots. Shoots of pruned, non-stressed plants were predominantly vegetative. Non-pruned non-stressed plants were typical of those growing in the field exposed to cool winter nights.

745

# BRANCH POSITION, DEFOLIATION, DISBUDDING AND GIRDLING ON FLORAL INITIATION, FLOWERING AND FRUIT SET OF OLIVE.

Gerardo Martinez-Díaz\*, J.A. Crisitóbal Navarro-Ainza and Raúl Grijalva-Contreras, INIFAP-CIFAPSON-CECAB. Apaxtado Postal 125, Caborca, Sonora, México. 83600.

Flower density, number of flowers per inflorescence and fruit set in 'Mission' 'Barouni' and 'Ascolano' olive trees were related to cardinal orientation of branches: branches located at W and N showed higher values than S and E branches. Observations about floral development indicated that floral initiation of cv Mission occurred earlier on N and W branches (Feb. 26th to March 7th) than on E and S ones (March 7th to April 26th). Defoliation on January 12th decreased number of inflorescences per branch, but such effect was counteracted if buds up or below the defoliated region were eliminated. Girdling decreased the action of desbudding, mainly if desbudding was performed above the defoliated region.

746

# THE EFFECTS OF BAGGING ON FRUIT SET AND FRUIT CHARACTERISTICS OF DATE PALM KHASTAWI CV. (PHOENIX DACTYLIFERA).

Essam A. Mawlood\*, H.H. Hamood, and E.S. Salah, Agriculture and Water Resources Research Center, Council of Scientific Research. Baghdad-IRAQ.

This experiment was conducted to study the effects of bagging on fruit set, fruit characteristics and yield of Khastawi Date Palm CV. Two different types of bags were used: cloth and paper. The spadices were covered immediately at two different times during the first season; one month and the second continued until harvest time. Since positive results were obtained during the season, two extra bagging treatments were added in the second season (2 and 3 months). Unbagged spadices were used as control for both seasons. The results indicated that there were no significant differences between the two types of bags. Moreover, bagging for either two or three months produced positive results in fruit set improvement and yield.

## 188 ORAL SESSION (Abstr. 747-753) FLORICULTURE: GREENHOUSE MANAGEMENT/NUTRITION

747

# SOIL MOISTURE TENSION-BASED IRRIGATION OF CONTAINER-GROWN PLANTS UNDER COMMERCIAL CONDITIONS.

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An irrigation system was developed to water container-grown ornamental plants so that soil moisture tensions could be continuously monitored and

controlled. Operation of such a system has been shown to significantly reduce the amount of water which must be applied to produce high-quality potted chrysanthemums. This presentation will focus on modification of drip irrigation systems in commercial production environments to irrigate based on soil moisture tension. High-quality plants were produced in commercial trials with such systems. In all cases significant economic savings due to reduced fertilizer and water application were observed. Furthermore, the amounts of irrigation water run-off were significantly lower than in systems where irrigation was controlled manually or with timers.

748

# LEACHATE LEVELS OF $\text{NH}_4^+$ , $\text{NO}_3^-$ AND P FROM NEPHROLEPIS 'GREEN VALLEY' DUE TO FERTILIZER SOURCE, IRRIGATION LEVEL AND TIME.

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Leaching of N into ground water has become a major pollutant in several areas of the U.S. The potential for regulation of environmental plant producers is increasing, but limited information is available on cultural management. This factorial experiment tested a liquid and a slow release fertilizer source at 3 irrigation levels (100, 200 or 300 ml/20 cm pot/2 times/wk) for  $\text{NH}_4^+$ ,  $\text{NO}_3^-$  and P found in leachate collected weekly for 12 weeks. Plant quality and fresh weight for all treatments was similar, but large variations occurred in  $\text{NH}_4^+$ ,  $\text{NO}_3^-$  and P levels in leachate due to irrigation level. Increasing irrigation level from 100 to 300 ml twice weekly resulted mainly in linear increases of  $\text{NO}_3^-$  present in leachate, with levels as high as 159 mg/l observed near the end of the production cycle.  $\text{NH}_4^+$  levels were most affected by irrigation and highest early in the experiment, but were generally lower than 1 mg/l. P levels ranged from 1.4 to 16.0 mg/l in leachate with responses to fertilizer source and irrigation mainly during the first 6 weeks.

749

# DEVELOPMENT OF A NUTRIENT SOURCE FOR SUSTAINING LOW CONCENTRATIONS IN GREENHOUSE SUBSTRATES

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A sustained release nutrient source suitable for maintaining steady, low (1 mM) N concentrations in the soil solution was sought as a component to be used in a system for reducing nutrients in the effluent of an open greenhouse cropping system. Several nutrient sources were evaluated as a N source incorporated singly in a medium of 1 sphagnum peat moss: 1 vermiculite and used to produce Chrysanthemum  $\times$  morifolium 'Sunny Mandalay'. All nutrients except N were applied additional to the sources tested. Sources tested included specific non-viable bacterial (B) and fungal (F) organisms from commercial biotechnological production lines, a microbial sludge mixture (S) from waste-water treatment, poultry waste-methane generator sludge (PS), micro-Osmocote (O), unsteamed bonemeal (BM), poultry feather meal (FM), and three-year aged pine needles (PM) at rates from 0.15 to 1.3 kg N-m<sup>-3</sup>. Based on periodic vacuum extracted soil solution analyses, leaf analyses, and plant growth, the efficacy of sources was in the order B, O > BM > S > PS > F, FM > PN. The 3 best sources provided sufficient N for 6 weeks; however, growth parameters did not differ from a complete liquid fertilization control until after 9 weeks. N in soil solution from the bacterial cells was at weeks 1, 3, 5, and 7: 142, 200, 73, and 3, mg-l<sup>-1</sup>, respectively.

750

# QUANTITIES AND FORMS OF NITROGEN UPTAKE THROUGHOUT DEVELOPMENT IN CHRYSANTHEMUM.

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Changes in quantity and form of nitrogen used were evaluated during development of *Dendranthema  $\times$  grandiflora* 'Iridon', 'Sequoia' and 'Sequest' grown in hydroponic solutions containing 28 ppm  $\text{NO}_3^-$  (as  $\text{Ca}(\text{NO}_3)_2$ ) and 28 ppm  $\text{NH}_4^+$  (as  $(\text{NH}_4)_2\text{SO}_4$ ). Four plants of each cultivar were harvested every ten days over ninety days. Data were collected on plant height, leaf number, flower bud diameter, and root and shoot dry weights. Nutrient solutions were changed every ten days and sampled at days 1, 5, and 10 of each cycle. Concentrations of  $\text{NO}_3^-$  and  $\text{NH}_4^+$  of nutrient solutions and dried plant tissues were determined by micro-Kjeldahl. Total tissue nitrogen was determined for 'Sequoia' by macro-Kjeldahl. Depletion of nitrogen from solutions approximated a 1:1 ratio for  $\text{NH}_4^+:\text{NO}_3^-$  throughout the crop cycle ( $r = 0.96$ ). Although the sample date  $\times$  cultivar interaction was significant for both forms of nitrogen, overall patterns of nitrogen uptake were similar among cultivars. Nitrogen uptake expressed per gram of tissue dry weight was greatest in the first month of development. However, total nitrogen

uptake was greatest from days 40 to 60. Developmental stages corresponding to this period are a cessation of new leaf development and flower bud diameters of approximately 1.0 cm. Nitrogen uptake decreased rapidly as flowers expanded. Correlations between morphological changes and nitrogen demands could maximize the efficiency of nitrogen applications.

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**EFFECT OF  $\text{NH}_4^+$ ,  $\text{NO}_3^-$ , AND  $\text{Cl}^-$  IONS ON ION UPTAKE AND SOLUTION pH IN HYDROPONIC CULTURE OF AGERATUM AND SALVIA**

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Ageratum and salvia were grown in hydroponic solutions containing either  $\text{NH}_4^+$ ,  $\text{NO}_3^-$ , or both  $\text{NH}_4^+$  and  $\text{NO}_3^-$  with or without  $\text{Cl}^-$  to study changes in solution pH and ion uptake rate. pH of both  $\text{NH}_4^+$  and  $\text{NH}_4^+ + \text{NO}_3^-$  solutions was steadily decreased as time passed. A drop in pH from 6.50 to 3.57 within 3 days was recorded with  $\text{NH}_4^+$ . The pH changes were also affected by the presence of  $\text{Cl}^-$ . The  $\text{NO}_3^-$  treatment maintained its initial solution pH over time regardless of the presence of  $\text{Cl}^-$ . pH change by ageratum was greater than that by salvia, especially when plants were in  $\text{NH}_4^+ + \text{NO}_3^-$  solution. N uptake was maximum in  $\text{NH}_4^+ + \text{NO}_3^-$  solution with  $\text{Cl}^-$ . Uptake of  $\text{NO}_3^-$  was suppressed by  $\text{NH}_4^+$ , but  $\text{NH}_4^+$  uptake was not affected by  $\text{NO}_3^-$ .  $\text{NH}_4^+$  and  $\text{NO}_3^-$  counteracted each other in influencing the  $\text{Cl}^-$  uptake. Uptake of other ion was also affected by plant species as well as N source and  $\text{Cl}^-$ . In ageratum transpiration rate was lowered by  $\text{Cl}^-$  in both  $\text{NH}_4^+$  and  $\text{NO}_3^-$  treatments.

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**INFLUENCES OF  $\text{NH}_4^+$  AND  $\text{NO}_3^-$  ON UPTAKE OF  $\text{Cl}^-$  IONS BY AGERATUM, PETUNIA, AND SALVIA**

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This study was carried out to determine the interaction among  $\text{NH}_4^+$ ,  $\text{NO}_3^-$ , and  $\text{Cl}^-$  ion uptake and to find the causes of  $\text{NH}_4^+$ -related toxicity symptoms in plants fed with  $\text{NH}_4^+$  as a sole nitrogen source. Seedling plants established in peat-lite and rockwool media were fed with nutrient solutions containing either  $\text{NH}_4^+$  or  $\text{NO}_3^-$  or both  $\text{NH}_4^+$  plus  $\text{NO}_3^-$  with or without  $\text{Cl}^-$ . Plants grown with  $\text{NH}_4^+ + \text{Cl}^-$  contained the highest levels of  $\text{Cl}^-$ . Plants fed with  $\text{NO}_3^- + \text{Cl}^-$  also showed high levels of  $\text{Cl}^-$  in the tissue. The growth and tissue  $\text{Cl}^-$  contents of plants fed with  $\text{NH}_4^+$  were not affected by changes in  $\text{Cl}^-$  concentration in the nutrient solution. Plants fed with  $\text{NH}_4^+$  that was ion-balanced by high levels of  $\text{SO}_4^{2-}$  plus low or no  $\text{Cl}^-$  still developed the  $\text{NH}_4^+$ -related toxicity symptoms. This indicates that  $\text{NH}_4^+$ -related toxicity symptoms occur independently of  $\text{Cl}^-$ . It was also shown that the activity of  $\text{Cl}^-$ , a counterion for  $\text{NH}_4^+$  uptake, was suppressed by  $\text{NO}_3^-$ .

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**PRODUCTION OF SOME FLOWERS IN HYDROPONICS AND SOILLESS MEDIA**

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Production of five commercial cut flowers in different culture media, namely, nutrient film technique (NFT), soilless media (perlite and an equal mix of perlite and peatmoss), and soil mix (2 sand : 1 loam by volume), was investigated in controlled fiberglass-house. Two rose varieties (*Rosa hybrida* var. Baccara and *Madina*); carnation (*Dianthus caryophyllus* var. William Sim); *Chrysanthemum morifolium* var. Delta, and *Dahlia hybrida* var. *variabilis* were used. Plants were watered as they needed by the same nutrient solution used for NFT.

Generally, growth and yield of Baccara and *Madina* roses, *Chrysanthemum* and *Dahlia* plants were superior in NFT than in the other media. On the contrary, the growth and yield of carnation plants were significantly greater in conventional soil or perlite and peatmoss mix than in NFT or perlite.

Flower crops grown in NFT generally reached harvest stage 5-10 days earlier than those grown in the other media except carnation plants. There were variations in the accumulation of N, P, K mg, Ca, and Fe in plant leaves among the various culture media.

**192 ORAL SESSION (Abstr. 754-761)**

**FRUIT CROPS:**

**STRESS PHYSIOLOGY**

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**WIND STRESS ON YOUNG ORCHARD TREES**

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Tree growth and leaf water stress measurements were taken on 3 year old Red Fuji apple and 5 year old Fayette peach trees under drip irrigation. Measurements on apples were taken from trees growing at specific distances away from a 6m high Eucalyptus windbreak perpendicular to prevailing winds and apple rows. Total wind run was measured in 3 locations within apple rows. Total branch growth and trunk circumference data can be related to windspeeds, apple tree row self sheltering, and shade from the windbreak. The most total growth occurred within a distance 42m from the wind break. Measurement on peaches were taken from trees growing down a slope. Constant windspeed and direction was collected from anemometers located at the top and bottom of the hill. Trunk circumference and total tree growth increased as wind exposure decreased. Trees exposed to 11.9 kph winds had a smaller leaf temperature-air temperature differential compared to trees exposed to 9.4 kph. Leaf stomatal resistance and water potential data suggest that trees exposed to wind were under water stress. Even a slight difference in wind exposure caused water stress responses.

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**LENTICEL HYPERTROPHY OF FLOODED MANGO TREES**

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One-year-old potted 'Peach' mango (*Mangifera indica* L.) trees were flooded at soil temperatures of 15, 22.5 or 30°C. Hypertrophied lenticels were observed after 5-6 days at 30°C and 6-8 days at 22.5°C, but were not observed after 30 days at 15°C. Cells of hypertrophied lenticels were more spherical and randomly arranged than those of nonhypertrophied lenticels, resulting in increased intercellular airspace. Lenticel hypertrophy also occurred on stems of trees which were kept moist from intermittent misting, and on excised and intact stem sections. Therefore, formation of hypertrophied lenticels in mango occurs independently of root anaerobiosis and is dependent on floodwater temperature.

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**PECAN TREE GROWTH, PRODUCTION, AND NUT QUALITY RESPONSES TO WATER STRESS**

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Pecan tree (cv. "Western Schley") water stress was numerically quantified with the crop water stress index (CWSI). The CWSI was used to schedule irrigation at increasing water stress levels to correlate the effects of water stress on tree growth, production, and nut quality from 1987 to 1989. Highest growth increases, production, and nut size were attained at lower water stress levels (CWSI = 0.08 to 0.14 units). Even moderate increases in water stress (CWSI > 0.20 units) decreased pecan tree growth and production, and significantly reduced nut size (P=0.01). A significant difference (P=0.05) in nut quality was measured only in 1988. Depending on yearly climatic variation, the amount of irrigation water required to maintain the CWSI below 0.14 units in the same orchard varied 44% over three years. The CWSI is a viable tool to assess pecan water stress.

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**CHARACTERIZATION OF PEACH ROOTS UNDER SEMIARID CONDITIONS INFLUENCED BY IRRIGATION TIMING**

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Field studies were conducted June 2, July 27, and October 15, 1988 to determine root concentrations within the dry and wetted soil of trickle-irrigated peach trees (Redglobe variety) in Windthorst fine

sandy loam soil. Two "dryland" and four irrigation treatments (based on time of year irrigation initiated and previous irrigation history) were used. A single soil core sample 2.2 cm in diameter and 80 cm deep was taken 50 cm from trickle emitters on each of 8 trees per irrigation treatment and a single sample taken the same distance from the trunk on the "dry" side of the 8 trees in each dryland treatment. Each core was sectioned into 20-cm increments, washed, roots collected, separated (small, feeder roots; large suberized roots), dried and weighed.

Analyses of data for the small, feeder roots showed a significant difference (0.01 level) in root density between treatments, between sample times (each treatment), and with depth (each treatment). Root concentrations were highest in soils that had received irrigation in previous years and also when irrigation was initiated early in the year. Root concentrations were also found to be highest in the top 20 cm of soil regardless of treatment.

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#### EFFECTS OF PREHARVEST IRRIGATION CUTOFF DURATION ON FRENCH PRUNE TREE PERFORMANCE

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Variable lengths of water deprivation immediately prior to harvest were imposed on mature French prune trees for four consecutive years. Irrigation cutoff durations were about 45, 37, 30, 22, 17 and 12 days prior to harvest during 1986-89.

Predawn leaf water potential best reflected water deprivation length and reached minimum values of about -1.5 MPa with the most severe cutoff. Magnitude of peak stomatal conductance was reduced and occurred earlier in the day with longer cutoff regimes.

Rate and time-course development of preharvest fruit drop was variable from year-to-year, but there were no significant differences in total drop between cutoff treatments. Only in the fourth year, following three years of no difference were tree fruit load and yield significantly reduced but then only with the most severe cutoff. Soluble solids were higher and drying ratios lower with the longer cutoffs. Fruit size was significantly reduced in the third year of the experiment. Trunk circumferences were significantly lower only with trees subjected to the longer cutoff regimes.

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#### INFLUENCE OF PREHARVEST IRRIGATION CUTOFF DURATION AND POSTHARVEST WATER DEPRIVATION IN ALMOND

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Previously well irrigated mature 'Nonpareil' almond trees (*Prunus dulcis*) were subjected to varying periods of water deprivation prior to harvest and then to either full or no postharvest irrigation. Eight preharvest water deprivation (PWD) lengths ranging from 14 to 63 days were evaluated on a sandy loam soil with a rooting depth of about 1.5 m.

Development of tree water deficits occurred rapidly following PWD. Predawn leaf water potential decreased to about -1.8 and -3.1 MPa after 10 and 20 days, respectively. Defoliation began about 30 days after PWD and trees subjected to more than 50 days completely defoliated. The rate of hull split was directly related to the PWD duration. With early cutoffs, the size of the hull split-arrested nuts at harvest was large compared with the same nut type in later cutoffs suggesting that as nuts develop, large nuts are preferential sinks for assimilates. Kernel size was only mildly reduced by PWD during the first study year. There was a trend toward lower total kernel yield with longer PWD as a result of smaller kernel girth but yield differences were not significant. The number of nuts remaining in the tree after shaking was not related to PWD. Bark strength increased after PWD with 10 to 14 days required to prevent shaker damage. Postharvest irrigation resulted in late season defoliation but no rebloom. Bloom density reductions in 1990 were related more to the lack of 1989 postharvest irrigation than to early PWD.

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#### LEAF ANATOMY OF SOME GRAPE CULTIVARS IN RESPONSE TO SALINITY

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The present investigation was carried out to determine the effect of salinity on three grapevine leaf anatomy. The experiment was conducted in box culture with two mixed salts (NaCl and CaCl<sub>2</sub>) at five concentrations (0, 1000, 2000, 3000 and 4500 ppm) and three cultivars, namely, 'Thompson seedless', 'Flame seedless' and 'Robby seedless'. Increasing salinity significantly reduced the total axes of the epidermis, assimilating, vascular and ground tissues of the leaf. It also changed the ratio of the upper to the lower epiderm tissue.

The differences among the three cultivars were not significant. The area of the palisade tissue was larger than the area of the spongy tissue in case of the control or 1000 ppm salinity treatments, while higher concentration of salinity resulted reverse in a situation. The xylem area was larger than that of the phloem at all concentrations under study. The area of parenchyma tissue was consistently larger than that of mechanical tissue.

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#### IMPACT OF SALINITY ON IRRIGATED MACADAMIA PRODUCTION

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Many areas in Hawaii with potential for growing macadamia lack sufficient rainfall. Ground water in these areas is generally brackish due to sea water intrusion. An experiment was started in 1984 to determine the response of young macadamia trees cv. 'Kau' (HAES 344) *Macadamia integrifolia* to salinity under field irrigated conditions. Treatments were rain only, freshwater, 500 and 1200 ppm salt as diluted sea water to simulate the ground water conditions.

Until mid 1989 trees were irrigated twice weekly to supply 100% ET (evapotranspiration) of the previous week based on a class A pan. No differences were detected among treatments on yield, trunk diameter, soil and tissue nutrient composition except trees in the rain only treatment less yield and trunk growth. Irrigation treatments were modified in mid 1989 to rain only, and twice weekly fresh water, 1200 and 2400 ppm salt at 50 and 75% ET. Effect on yield, trunk diameter, soil and tissue nutrient composition in the 1989-90 season will be reported.

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## 193 ORAL SESSION (Abstr. 762-769)

### CROSS-COMMODITY: BREEDING II

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#### DIALLEL ANALYSIS OF ROUGH BLOSSOM-END SCARRING IN TOMATO

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A half diallel including 11 parents was conducted under high temp. conditions in Florida and low temp. conditions in Israel. Blossom scar (BS) size was measured relative to the fruit size for 20 mature fruits per plot. Griffing's analysis showed that both GCA and SCA effects were highly significant at both locations ( $p < 0.0001$ ). Analysis according to Hayman indicated no epistatic effects. In both environments, additive and dominant gene action was significant ( $p < 0.0005$ ), although the additive gene effects were most important. Averaged over all loci, the incomplete dominance was in the direction of small BS. Narrow sense heritability estimates were 0.62 and 0.57 for Florida and Israel, respectively. Combined analysis showed that the genetic system was unstable over the 2 environments, as both additive and dominant gene effects interacted significantly with environment ( $p < 0.0001$ ). The implication for breeding programs is that hybrid performance should be tested at several locations to insure stability of small BS.

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#### FLOODING TOLERANCE IN SPINACH (*Spinacia oleracea* L.)

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Spinach (*Spinacia oleracea* L.) varies in tolerance to saturated soil conditions. Plant vigor was assessed for plants flooded in autoclaved and nonautoclaved field soil. Decline of vigor was more rapid for plants flooded in nonautoclaved field soil, indicating that flooding tolerance may be influenced by soil borne pathogens.

# CHARACTERS ASSOCIATED WITH YIELD STABILITY OF IRISH POTATO GENOTYPES IN GEORGIA

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Three experiments, each with 100 potato (*Solanum tuberosum* L.) genotypes, were conducted using triple lattice designs from 1988-1989. The use of lattice designs did not improve the efficiency of these experiments over randomized complete blocks. The phenotypic stability of tuber yields of 91 genotypes, common to three experiments, was measured by regression of genotype means over environmental means. Regression coefficients indicated that 60 days after planting (DAP), genotypes adapted to high yielding environments ( $b > 1$ ), had significantly higher tubers/plant, leaf area index, and yield/plant, as compared to genotypes suited to low-yielding environments. At final harvest, approximately 100 DAP, genotypes specifically adapted to high yielding environments had significantly higher tubers/plant and yield/plant than genotypes adapted to low yielding environments ( $b < 1$ ). Green Mountain, Kennebec, and Norchip were adapted to high-yielding environments whereas La Chipper, Ontario, and Superior were adapted to low-yielding environments.

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# ENVIRONMENTAL EFFECTS ON YIELD AND INSECT DAMAGE OF STORAGE ROOTS AND FOLIAGE OF SWEET POTATO IN PERU

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Yield and insect damage of 50 potato cultivars, representative of genetic variation found in CIP germplasm collection, were evaluated over two years in a wide range of environmental conditions throughout Peru, from 4°S to 17°S, including coastal desert, cool highland and humid jungle, at altitudes from 180m to 3280m. Storage root and foliage yields were related to maximum and minimum temperature, photoperiod, precipitation, soils, and insect damage. Genotypic yield varied considerably from one location to another. Jonathan (Peruvian cultivar) produced well in Cañete (coastal desert) but not in the jungle or highlands. Jewel (US cultivar) produced well in Yurimaguas (jungle) but not in coastal deserts. Pesticides were not used but several cultivars had little or no insect damage, others were badly damaged. Some cultivars produced a reasonable yield over a wider range than did others. Results suggest that a cultivar can be strongly adapted to a particular set of environmental conditions. Data provide valuable information for growers-breeders.

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# EFFECTS OF SUPPLEMENTAL LIGHTING AND GENOTYPE ON FERTILITY OF PELARGONIUM × DOMESTICUM

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Cultivars of the clonally propagated *Pelargonium* × *domesticum* are generally limited in fertility which impedes the development of improved cultivars. The purpose of this study was to determine the effects of supplemental high intensity discharge (HID) lighting upon flowering and seed set and to screen a number of cultivars and breeding lines for fertility.

Plants were provided one of three supplemental HID lighting treatments: 1) Control (no HID). 2) HID from sunrise to sunset (times adjusted weekly). 3) HID for 16 hours daily. As they became available, 14 flowers per plant were emasculated and pollinated with pollen which had been bulked from approximately 20 unrelated plants.

Plants given 16 hour HID tended to be more compact and flower earlier than control plants. There were large differences between cultivars in fruit development and seed set with 83-11-3 and Elsie Hickman being among the most fertile and Grand Slam one of the poorest.

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# ESTIMATION OF VARIANCE COMPONENTS AND HERITABILITY FOR FLOWERING TIME AND CUT-FLOWER YIELD FOR THE DAVIS POPULATION OF GERBERA USING RESTRICTED MAXIMUM LIKELIHOOD (REML)

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Additive genetic components of variance and narrow-sense heritabilities were estimated for flowering time and cut-flower yield for generations 8-13 of the Davis population of gerbera, using the

least squares (LS) and restricted maximum likelihood (REML) methods. Estimates of heritability for flowering time were 0.54 and 0.50 using REML and LS, respectively, indicating a close agreement between the two methods. However, estimates of heritability for cut-flower yield were 0.30 and 0.46 from REML and LS. This may result from the fact that cut-flower yield was selected in each generation; flowering time was not. Realized heritability for cut-flower yield was estimated to be 0.26 which agreed more closely with the heritability estimated from REML. The advantages of REML, and its applications in the estimation of components of genetic variance and heritability of plant populations are discussed.

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# THE BIPLLOT DISPLAY OF THE TALL FESCUE TURF VARIETY TRIAL DATA

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Tire interpretation of variety trials conducted with many genotypes (G) grown in many environments (E) is usually complicated by the presence of the significant  $G \times E$  interaction. The common statistical analysis using ANOVA and linear regression techniques are often inadequate to study the complex two-way data structure. The **biplot**, a multivariate technique provides, a graphical representation of the interaction, which allows the response of each G in each E to be displayed in a two dimensional plot. It displays not only the configuration of G and E, but it also relates the two. The importance of biplot display is illustrated by using the tall fescue variety trial data on mean quality ratings published by the National Turfgrass Evaluation Program. The biplot displays about 60% of the information in the 24 (G) × 23 (E) data matrix. Environments TX3 and GA1 responded differently from other environments. Based on the biplot display genotypes are grouped and their significance will be discussed.

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# ANALYSIS OF POTENTIAL AND STABILITY ACROSS ENVIRONMENTS OF NINE APPLE ROOTSTOCKS IN THEIR INFLUENCE ON GROWTH AND YIELD

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Nine apple rootstocks grafted with 'Starkspur Supreme Delicious' were evaluated in 19 states over 9 to 10 years by the NC 140 Regional Project as a randomized complete block with 10 replications in each site. Effects on trunk cross-sectional area (TA), cumulative yield per tree (Yc), and cumulative yield efficiency ( $YEC=Yc/TA$ ) were evaluated. Rootstock differences in mean potential (mean performance at the mean site) and environmental stability (slope across sites) were compared by analysis of rootstock performance within a site linearly regressed on mean performance of all rootstock in that site. MAC 24 had the highest mean potential of Yc and TA with lowest stability, giving this rootstock the highest Yc and TA in best sites, and lowest in poor sites. M.27 EMLA was the opposite, having low potential and high stability in Yc and TA. In YEC, M.27 EMLA and MAC9 had high potential and low stability, while OAR1, M.7 EMLA, and especially MAC 24 were the opposite. YEC of Ott.3 and M.26 were average in both respects. M.9 had high potential YEC with average stability. M.9 EMLA was unique in having both high potential and high stability of YEC.

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## 194 ORAL SESSION (Abstr. 770-776) CROSS-COMMODITY POSTHARVEST PHYSIOLOGY II

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770

# VARIATION IN FRUIT QUALITY CHARACTERISTICS OF PRICKLY PEARS (*OPUNTIA* SPECIES)

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This paper presents the results from a two-year study on fruit quality characteristics of prickly pear accessions belonging to five *Opuntia* species (*O. ficus-indica*, *O. hytiacantha*, *O. inermis*, *O. linderheimeri* and *O. megacantha*) from a germplasm collection at Texas A&I University. Fruit soluble solids, pH, titratable acidity and ascorbic acid contents were determined using standard procedures. Significant differences in fruit soluble solids and ascorbic acid contents were observed. Accessions belonging to *O. ficus-indica* consistently had the

highest soluble solids (> 12%) and ascorbic contents (>24mg/100g) while accessions belonging to *O. lindheimeri* consistently had the lowest soluble solids (<8%) and ascorbic acid contents (< 10mg/100g). Fruit acidity was generally low (<0.19%) for all the species. The results suggest potential for developing prickly pears for the fresh fruit market in south Texas.

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#### SENSORY ANALYSES OF NETTED MUSKMELON FRUIT QUALITY AND PREFERENCE

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Analyses of sensory attributes from 19 netted muskmelon (*Cucumis melo* L.) cultivars and breeding lines showed that flavor, ( $r = .92$ ) had the highest significant correlation with overall fruit acceptance, while appearance ( $r = .72$ ), color ( $r = .71$ ) and internal color ( $r = .68$ ) were secondary, and texture ( $r = .41$ ) was not significantly correlated with overall fruit acceptance. Chemical attributes of soluble solids, fresh weight, dry weight, beta-carotene, firmness, fructose, glucose, sucrose, and total sugars showed that total sugars per g fresh weight had the highest significant correlation ( $r = .68$ ) with overall fruit acceptance. Total sugars per g fresh weight was significantly correlated with flavor ( $r = .65$ ). Although, sugars were correlated with flavor, sugars when compared to flavor were less important in determination of overall muskmelon fruit preference.

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#### SENSITIVITY OF CUCUMBER LINES TO CHILLING INJURY

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Cucumber fruit (*Cucumis sativus* L.) of 13 cultivars were chilled at 2.5C for up to 10 d. Pitting scores after 8 d at 2.5C and 6 d at 20C ranged from 0.0 (none) in 'HP 138' to 7.7 (severe) in 'Poinsett 76' fruit. Ion leakage, as the increase in conductivity in a 0.3 M mannitol solution bathing excised disks of mesocarp tissue and expressed as % of the total ion content of the tissue, was lowest in 'MDR I' (4.5%) and highest in 'HP 159' (11%) after 6 d at 2.5C. After 10 d at 2.5C, however, the lowest was in 'Navajo' (5.5%) and the highest in 'Poinsett 76' (15%). Resistant lines, e.g., 'Dasher II' and 'HP 138' showed ion leakage of 7.6% and 5.4% after 6 d, and 8.4% and 7.5% after 10 d. Exudates from cut fruit were collected on filter paper. The fresh and dry wt of exudates from fruit held 8 d at 12.5C ranged from 144 to 346 mg and 16 to 47 mg, respectively. Conductivity of the exudates was highest in 'PS 34885' (177 uSiemen/cm) and lowest in 'Rawa' (83 uSiemen/cm). The fresh wt of exudate from 6 lines ranged from 99 to 164 mg after 10 d at 2.5C followed by an additional 2.4 d at 20C. The % solid-of the exudates was higher in more resistant lines, e.g., 'Dasher II' (8%) and 'HP 138' (4%) than in more sensitive lines, e.g., 'Poinsett 76' (2%) and 'MDR I' (2%). Conductivity of the exudates from chilling sensitive lines were higher than from resistant lines, 60 vs. 30 uS/cm, respectively.

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#### HOLDING LEMON FRUIT AT 5 OR 15C BEFORE COLD TREATMENT REDUCES CHILLING INJURY

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An approved quarantine treatment for Tephritid fruit fly control of citrus fruit requires fruit be held at 0.0-2.2C for 10-22 days, depending on fruit fly species involved and actual temperature attained. However, this treatment causes chilling injury (CI) in California-Arizona desert lemons harvested in late summer or early autumn. We found that temperatures at which lemons are held before cold treatment affects the susceptibility of lemon fruit to CI. Commercially packed lemons obtained from Yuma, AZ packinghouses in Sept.-Nov. 1987 and 1988 were held at 1C for 3 or 6 weeks, or cured for one week at 5, 15 or 30C, or at 15C for one week, followed by 30C for one week, before receiving the 1C cold treatment. Lemons cured one week at 5 or 15C before the cold treatment developed at least 25-30% less CI during 4 weeks peat treatment storage at 10C than noncured fruit. The other curing treatments were not as effective for reducing CI.

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#### ETHYLENE PRETREATMENT ALLOWS EARLY HARVEST OF CARAMBOLA

Steven A. Sargent\* and Jeffrey K. Brecht, Vegetable Crops Department, IFAS, University of Florida, Gainesville, FL 32611

Carambolas (*Averrhoa carambola* L., cv. Arkin) were harvested at colorbreak (CB) and light green (LG) ripeness stages,

commercially packed and cooled. The next day the fruit were treated as: Control (ungassed): CB, LG; Ethylene pretreatment (ETH) @100ppm: LC for 1, 2 or 3 days at 20°C or 25°. After pretreatment the fruit were stored at 5°. After 1, 2, 3, 4 weeks, 10 fruit from each treatment were removed from storage and placed at 20°. Fruit color and decay were rated daily until 80% of the fruit in each treatment reached the yellow ripeness stage, at which time external color, total soluble solids (TSS), pH and total titratable acidity (TTA) were determined. Carambolas harvested at the LG stage can be ripened to good quality with ETH pretreatment. For two weeks storage at 5°, 2 days ETH are necessary at 20° or 25° to initiate ripening. For three weeks storage, 3 days ETH are required at 20°, and 2 or 3 days ETH are required at 25°. Fruit stored four weeks were of fair quality. LG with slower ripening initiation developed chilling injury during storage; the fastest initiation had the best color but the shortest marketing life. Fruit harvested CB had slightly higher TSS than ETH-treated LG but pH and TTA were similar.

775

#### EFFECT OF O<sub>2</sub> ON NORMAL AND C<sub>2</sub>H<sub>4</sub>-STIMULATED SWEET POTATO RESPIRATION

Dingbo Zhou\* and Theophanes Solomos, Department of Horticulture, University of Maryland, College Park, MD 20742

It is known that pure O<sub>2</sub> enhances in sweet potato roots the respiratory increment produced by C<sub>2</sub>H<sub>4</sub> (Theologis and Laties, 1982, Plant Physiol.). Our experimental results indicates that the decrease in respiration with decreasing O<sub>2</sub> concentration is due to the restriction of an "oxidase" whose apparent Km for O<sub>2</sub> is 5-6 fold higher than that of cytochrome oxidase. The magnitude of the apparent Km for O<sub>2</sub> is affected by the diffusion of O<sub>2</sub> and experiment conditions. The effect of O<sub>2</sub> on respiratory rise produced by C<sub>2</sub>H<sub>4</sub> is due to the curtailment of C<sub>2</sub>H<sub>4</sub> action rather than to respiration as such. The apparent Km for O<sub>2</sub> of this system is larger than that of respiration.

776

#### RESPONSES OF PAPAYA TO SHORT-TERM EXPOSURE OF INSECTICIDAL O<sub>2</sub> ATMOSPHERE

E.M. Yahia\*, M. Rivers and O. Hernández, Centro de Investigación en Alimentación y Desarrollo, A.C. Hermosillo, Sonora, Mexico.

Papaya fruits were exposed to a continuous flow of an atmosphere containing less than 0.5% O<sub>2</sub> (the balance is N<sub>2</sub>) for 0 to 5 days at 20°C. Fruits were evaluated every day after exposure to low O<sub>2</sub> atmosphere, and simultaneously after 3 days in air at 20°C. During every evaluation period part of the fruits were promptly frozen for the analysis of the activity of the enzymes alcohol dehydrogenase (ADH), pyruvate decarboxylase (PDC), and lactate dehydrogenase (LDH), and pyruvic acid. The rest of the fruits were evaluated for flesh firmness, external and internal appearance, incidence of decay, and presence of off-flavors. Fruits had major decay problems and presented some off-flavors after 3 days in low O<sub>2</sub> and 3 days in air at 20°C. The intolerance of the fruit to low O<sub>2</sub> is correlated with an increase, after 3 days, in the activity of ADH and PDC but not with the activity of LDH. On the basis of these results, it is concluded that insecticidal O<sub>2</sub> atmosphere can be used as a quarantine insect control treatment in papaya for up to 3 days without the risk of significant fruit injury.

## 36 WORKSHOP 1 (Abstr. 780-784)

780

#### PLANTS AND HUMAN CULTURE

Candice A. Shoemaker\*, Department of Horticulture, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061

Plants are a part of many rituals and celebrations and they influence our language, art, and literature. At the First National Symposium on The Role of Horticulture in Human Well-Being and Social Development, a session on Plants and Human Culture was held. A review will be given of the seven oral presentations from this session and the discussion which followed. Some of the topics presented included the role of the corporate garden in the cultural activities of the community, the role of horticulture in holiday celebrations, the role of flowers in the bereavement process, and floral symbolism in paintings. Actions which horticulturists can take to promote horticulture within the cultural setting will be presented.

# PLANTS AND THE COMMUNITY: PLANTS AND GARDENING INFLUENCE PEOPLE SOCIALLY AND ECONOMICALLY

Virginia I. Lohr, Department of Horticulture and Landscape Architecture, Washington State University, Pullman, WA 99164-6414

Evidence is growing that people exposed to environmental and mental stress benefit from having plants in their communities and from working with those plants in gardening and related activities. The benefits to the community range from improved social interactions to reduced littering. Feelings of self-confidence and self-worth are improved. Economic conditions can be improved: vegetable production reduces the need for individuals to spend money on food, and community improvement initiated by flower gardening increases property values. Some of these benefits are well-documented, while others are primarily supported by a long history of anecdotal evidence. More research is needed to fully document the importance of community gardening efforts and to justify expansions in these programs.

782

## DEVELOPING A CONCEPTUAL FRAMEWORK

David W. Bradshaw\*, Department of Horticulture, Clemson University, Clemson, SC 29634-0375

The keynote address for this session was presented by Drs. Rachael and Stephen Kaplan. They presented the concept of "Thereness" - that the knowledge that the availability of a good view of vegetation from the workplace was more important to the psychological well-being of workers than the actual use of that view. M.K. Honeyman then presented results of a study which showed that vegetation does contribute to psychological well-being, and the lack of vegetation may create stress. Dr. E. Matsuo, in his paper, stated that all human creative actions are motivated by the urge to either foster or to acquire, and to be kept from either of these two would prevent us from living a fulfilled life. He also cautioned that we should account for the value of horticulture as a part of human life rather than just report the dollar value of the economics of horticulture.. Dr. B. Hull then stated that community is the overlapping of the extensions of the self-images of the people within that community. A. Mukherjee reported that community, state and regional planning must be coordinated to protect existing farms, watersheds and views as urban developments spread into rural areas. With time remaining, Bilge Friedlaender made an oral presentation of her poster outlining the making of seven community gardens, and closed with a moving statement of our responsibilities for the stewardship of our earth.

783

## HORTICULTURAL THERAPY

Joel Flagler, Rutgers University Cooperative Extension, 327 Ridgewood Avenue, Paramus, N.J. 07652

It has been observed that the process of horticulture can help to heal physical, mental, and social disabilities. Professionally trained horticultural therapists prescribe and administer planting and gardening activities to provide benefits to people of all ages and abilities. Horticultural therapy programs are now commonplace in hospitals, geriatric centers, schools, rehabilitation facilities, community gardens and prisons. One common goal in all of these programs is to help heal, teach and retrain individuals through the use of plants.

As a result of repeated successes, horticulture is being widely accepted as an effective therapeutic tool. Research is underway to measure the effectiveness of horticultural therapy in clinical and correctional settings. Databases are being developed to document and substantiate the beneficial effects of horticulture on human well-being. With such research results we can better understand the value of horticultural therapy in the recovery and rehabilitation processes.

784

SUMMARY OF RESEARCH IMPLEMENTATION SESSION (April 21, 1990). Barry Adler\*, O. M. Scott & Sons, Marysville, Ohio 43041

Summary and discussion to include the keynote topic RESEARCH IMPLEMENTATION by Diane Relf; contributed papers -- THE CHICAGO BOTANIC GARDEN: ITS ROLE IN THE ECONOMIC AND SOCIAL GOALS OF CHICAGO, by Sue Burd Brogdon, NATIONAL SURVEY OF ATTITUDES TOWARD PLANTS AND GARDENING, by Bruce Butterfield\* and Diane Relf, USING AN EXTENSION APPROACH TO IMPLEMENT RESEARCH RESULTS IN THE FLOWERING PLANT INDUSTRY, by Kevin Grueber, BEYOND ROMANTICISM: THE SIGNIFICANCE OF PLANTS AS FORM IN THE HISTORY OF ART, by Rhonda Roland Shearer, PEOPLE AND PLANTS: A CASE STUDY IN THE HOTEL INDUSTRY, by Michael Evans; and a brief review of posters.

## 46 WORKSHOP 2 (Abstr. 785-787)

785

MOLECULAR ANALYSIS OF HEAT STRESS PROTEINS IN HIGHER PLANTS Elizabeth Vierling, Department of Biochemistry, University of Arizona, Biological Sciences West, Tucson, AZ 85721.

When plants experience high temperature stress, they respond by synthesizing a discrete set of proteins called heat shock proteins (HSPs). This response is not unique to plants, but is observed in all other eukaryotes. It is now known that the HSPs are evolutionarily conserved proteins, and furthermore, that HSPs function not only during stress, but also during normal growth and development. My laboratory has characterized several of the major groups of HSPs in higher plants. We have cloned genes encoding plant HSP70 proteins and low molecular weight (LMW) HSPs (17-23 kDa). Using this information we have investigated the expression of HSPs both in the field, and under laboratory conditions which mimic field situations. We have determined the temperature limits for expression of HSPs in vegetative tissues, and have also found that HSPs are frequently produced in plant reproductive structures, even in the absence of stress. As a first step toward understanding HSP function, we have characterized the intracellular localization of HSPs. Results show that there are unique HSPs in the cytoplasm, chloroplast and endomembrane system. These ubiquitous proteins appear to play essential roles in many cellular processes.

786

## HIGH TEMPERATURE RESPONSE IN BEAN-PHYSIOLOGICAL CONSIDERATIONS.

Paul H. Li, Laboratory of Plant Hardiness, Dept. of Hort. Sci., University of Minnesota, St. Paul, MN 55108.

The common bean (*Phaseolus vulgaris* L.) is a heat-sensitive plant species in which excessive abscission of reproductive organs occurs during hot weather. This results in yield reductions, and, in extreme heat stress, plants produce few or no pods. We evaluated 74 bean genotypes in terms of leaf heat tolerance (HT) and leaf heat acclimation potential (HAP), as expressed by heat killing time (HKT), the time in minutes needed to cause a 50% electrolyte leakage from leaf tissue heated at 50°C. Leaf HT is defined as the leaf HKT of plants without prior conditioning at 37°C day/night temperature and leaf HAP as the change in leaf HT following exposure of the plant to 37°C day/night for 24-h. Among 74 bean genotypes examined leaf HT ranged from 5 to 30 min HKT, whereas leaf HAP ranged from 35 to 130 min HKT. Positive significant correlations were observed between leaf HAP and post-stress performance in photosynthetic activities, plant dry weight, pod set, pod weight and yield among bean genotypes. Correlations, however, were not significant between leaf HT and post-stress performance.

A relationship between heat resistance, consisting of the combination of HT and HAP, and heat injury is proposed. Interpretation of the differential amounts of heat injury among genotypes having different HAP, is discussed. We view leaf HT and leaf HAP as two distinguishable phenomena. We suggest that in breeding programs HAP may be the more important of the two, and should be evaluated as a selection criterion for improving crop performance in high temperature environments.

787

## HIGH TEMPERATURE RESPONSE IN BEAN -- BREEDING CONSIDERATIONS

David W. Davis\* and Karl J. Sauter, Department of Horticultural Science, University of Minnesota, St. Paul, MN 55108

Attention has been given in recent literature to crop breeding for heat tolerance, but, as with certain other physiological traits, such as photosynthetic efficiency, practical gain has lagged. The question remains as to whether heat tolerance can be improved, and, if so, if it can most efficiently be improved by a holistic approach, as in breeding for yield following timely high temperature levels in the field environment, or whether the breeding for heat (and drought) tolerance components in the laboratory would be feasible. At issue is the identification and repeatability of key plant responses, such as cell membrane damage, heat shock protein formation, increased ethylene output and other responses, and the relevance, effectiveness and cost of screening for such traits. Results from our laboratory, and the work of others, will be reviewed.



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## 47 WORKSHOP 3 (Abstr. 788)

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788

### BIOTECHNOLOGIES AND FOOD: ASSURING THE SAFETY OF FOODS PRODUCED BY GENETIC MODIFICATION

William R. Romig\* DNA Plant Technology, 2611 Branch Pike, Cinnaminson, NJ 08077

Scientific experts from universities, government laboratories and food and biotechnology companies, have spent more than two years researching the report, titled, "Biotechnologies and Food: Assuring the Safety of Foods Produced by Genetic Modification."

The IFBC report outlines criteria to determine the safety of foods or ingredients developed through genetic modification. Criteria focus on: foods and food ingredients derived from microorganisms; simple chemicals and simple mixtures; and whole foods and other complex mixtures.

The IFBC report presents "decision trees" to determine the safety of foods from non-traditional genetic modifications, which include such processes as recombinant DNA, cell fusion and direct mutagenesis. The decision trees comprise a series of detailed questions concerning the genetic origin, composition and safety of the food or food ingredient and culminate in a decision to accept, reject or subject the test material to further study.

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## 61 WORKSHOP 4 (Abstr. 789-790)

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789

### ROOT TURNOVER: METHODS OF ANALYSIS

David Eissenstat, Citrus Research and Education Center, University of Florida, Lake Alfred, FL 33850-2299

Root turnover has been determined primarily in ecosystem studies with perennial vegetation since it is a key for understanding primary production and nutrient cycling. These topics have become of interest to agriculturalists as well. Apart from ecosystem-level questions, there has been limited study of the environmental factors that influence root death. Many techniques have been devised to estimate root turnover, each with its own set of limitations. In forest ecosystems, one of the most popular methods of estimating root production turnover is sequential biomass sampling. However, this method fails to account for the simultaneous production and decomposition of roots during active periods of net biomass increase. A second method is a mesh-bag technique, which estimates root production/turnover from the amount of new roots that grow into a mesh bag. A method that uses radiocarbon is one of the most accurate, since estimates of root turnover include losses by exudation, cortical cell sloughing, as well as root loss. A fourth method of estimating root turnover involves tracking the roots visible behind transparent glass or plastic. Ultimately, the choice of method depends to a large extent on the type of plants used in the investigation and resources available for study.

790

### PHYTOHORMONE ANALYSIS WHAT DO THE NUMBERS MEAN?

Jerry D. Cohen\* and Janet P. Slovin USDA-ARS Plant Hormone Laboratory, Beltsville Agricultural Research Center, Beltsville, Maryland 20705 and Dept. of Botany, Univ. of Maryland, College Park, MD 20742

The literature is full of different techniques and approaches to the isolation, purification and quantitative analysis of plant hormones. From this body of literature it is possible to deduce that 1) a lot of investigators are interested in how much of these compounds are in plants and 2) that the techniques for phytohormone analysis are still largely "under development". This talk will discuss different approaches to hormone analysis, suitability of each approach, and criteria for the evaluation of techniques and results. The goal will be to highlight points that are important to obtaining reliable analytical information and knowing what to do when problems occur. Nevertheless, having reliable numbers is frequently only the first step in understanding hormonal systems involved in plant development. It is often the case that the expected results are not what is found in experiments involving plant

hormone quantitation. We will consider experimental design, tissue localization, developmental stages, sampling and extraction procedures, and the limits of what to expect when "dogma confronts reality". *Work reported was supported by grants from the National Science Foundation DCB-8917378, USDA-CRGO 89-3721-4734, US-Israel BARD US-1362-87, and by funds from the USDA Agricultural Research Service.*

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## 62 WORKSHOP 5 (Abstr. 791-792)

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791

### COMMERCIAL APPLICATIONS OF EXPERT SYSTEMS IN APPLE PRODUCTION

R. M. Crassweller\*, J. W. Travis, P. H. Heinemann and E. G. Rajotte, 102, Tyson Building, Penn State University, University Park, PA 16802

Apple orchards are highly diversified and complex ecological and economic systems. Production is affected by a wide range of insects, diseases, weeds, and mammalian pests. The incidence of these pests is often dependant upon climatological effects; and the microclimate within orchards. An expert system, a form of artificial intelligence, has been developed and commercially released to apple growers that utilizes weather data to make recommendations regarding production decisions. Users of the system are instructed on how to establish a weather station, and to collect, and input weather data from the farm. The information is utilized to calculate disease infection periods and pesticide residues to arrive at a control recommendation. Other weather dependant modules include the scheduling of trickle irrigation as well as water application rates during a frost. An interactive demonstration of the system will be presented to the group.

792

### DEVELOPMENT AND IMPLEMENTATION OF SIMULATION MODELS

Kent D. Kobayashi, Department of Horticulture, University of Hawaii at Manoa, Honolulu, HI 96822 U.S.A.

A simulation model consists of equations that represent the important relationships between components in a system, e.g., a plant or plant part. One of the purposes of simulation models is to simulate plant growth or plant growth processes to help further our understanding of plant growth and development. Simulation models are mechanistic or process based models that account for the physiological processes occurring in the system.

Model development involves several steps. We define the problem and defuse the system, its entities, their attributes, and important relationships. A conceptual model is often expressed visually in a relational diagram showing the components and their relationships. This diagram is formally expressed as a simulation model through the use of equations repenting the relationships in the system. We often make assumptions regarding the components and their relationships to simplify the model or because of a lack of knowledge. Simulation models are generally written using a simulation language such as CSMP or STELLA® or with a programming language such as FORTRAN or BASIC. The model is verified through checking the appropriateness of the relationships and the integrity of the computer program. The model is then validated through seeing bow well it simulates the behavior of the system. Simulation models provide additional insights by enabling us to ask "What if" questions by changing of the conditions of the model and seeing the resulting changes in plant growth.

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## 64 WORKSHOP 6 (Abstr. 793-796)

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793

### BREEDING OF *RHIPSSALIDOPSIS* AND *SCHLUMBERGERA*

Thomas H. Boyle, Department of Plant & Soil Sciences, University of Massachusetts, Amherst, MA 01003

*Rhipsalidopsis* (Easter cactus) and *Schlumbergera* (Thanksgiving and Christmas cactus) are two genera of epiphytic cacti endemic to southeastern Brazil. *Rhipsalidopsis* is comprised of two species (*R. gaertneri* and *R. rosea*) and *Schlumbergera*

contains five species (*S. opuntioides*, *S. obtusangula*, *S. orssichiana*, *S. russelliana*, and *S. truncata*). There is considerable potential for the improvement of commercial cultivars in both genera. Flower color and form, plant habit, postharvest performance, and the responsiveness to floral induction treatments are selection criteria used in breeding of *Rhipsalidopsis*. The selection criteria used in breeding of *Schlumbergera* are flower color and form, growth rate, phylloclade size and shape, plant habit, and the critical daylength for flowering. Inbreeding depression, self-incompatibility, and a long generation time (1.5 to 3 years) are impediments to breeding in both genera. Interspecific hybridization has been performed in *Rhipsalidopsis* and *Schlumbergera*, and significant phenotypic variation has been observed within interspecific hybrid populations.

794

#### IMPROVEMENT OF NEW GUINEA IMPATIENS BY INTERSPECIFIC HYBRIDIZATION

Loren C. Stephens\* and Robin L. Fruth, Department of Horticulture, Iowa State University, Ames, IA 50011

New Guinea Impatiens cultivars, *I. hawkeri* Bull., are susceptible to hot, windy conditions throughout much of the Midwest and Western U.S. Certain Indonesian Impatiens from Java (*I. platypetala* Lindl.) and Celebes (*I. aurantiaca* Teyssm.) are much more heat-tolerant. Interspecific hybrids involving Java and Celebes Impatiens with the New Guinea species have been produced, but lack of fertility has been a persistent problem, unless amphidiploids are produced. Because selection is difficult in amphidiploid populations, other methods of recovering fertility have been investigated. Some interspecific hybrid fertility has been obtained from crossing Impatiens 'Tangelow' with a Java × New Guinea hybrid. Evidence will be presented on the role of the Celebes genome in female fertility, and the role of unreduced pollen in the Java × New Guinea hybrid. Approaches to understanding and overcoming sterility in Impatiens interspecific hybrids will be discussed.

795

#### LILACS AND OTHER WOODY ORNAMENTAL FOR ALL SEASONS

Owen M. Rogers\*, Plant Biology Department, University of New Hampshire, Durham, NH 03824

Current lilac breeding programs at the University of New Hampshire focus on the later (June) blooming species of *Syringa* with goals of extending the season of bloom selecting slower growing forms and developing lines with double flowers. Progress toward these goals and others, e.g., true dwarfs, will be discussed and illustrated.

Every university in the northeast includes woody ornamentals in its program to some degree. The University of New Hampshire is an official test site for ornamental from NE-9 and NC-7 germplasm programs and the National Arboretum's new introduction program. The value of these programs and their future direction will be discussed.

796

#### GENETICS AND BIOCHEMISTRY OF INSECT AND MITE RESISTANCE IN GERANIUM

Richard Craig\*, Richard A. Grazzini\* and R.O. Mumma  
Departments of Horticulture and Entomology, Penn State University, University Park, PA 16802

Resistance to mites and small insects in geranium results from the production of a viscous exudate on tall glandular trichomes present on the plant surface. This exudate exhibits sticky-trap properties immobilizing pests and reducing feeding and fecundity. The exudate is composed of long-chain 6-alkyl salicylic acids known as anacardic acids. The exudate of resistant plants contains 86% unsaturated anacardic acids. Susceptible genotypes possess fewer tall glandular trichomes and a trichome exudate which is dry and ineffective in trapping pests. The exudate from susceptible plants contains 70% saturated anacardic acids, thus explaining the physical state of the exudate. A single dominant locus controls the production of predominantly unsaturated versus saturated anacardic acids and thus resistance versus susceptibility. Other loci condition the ratio of C22:C24 unsaturated anacardic acids and the density of tall glandular trichomes. Current research involves the elucidation of the enzymatic pathway(s) involved in anacardic acid biosynthesis, identification of the regulatory enzymes and isolation of the mRNA transcripts associated with pertinent genes.

## 80 WORKSHOP 9 (Abstr. 797-798)

797

#### GENETIC MANIPULATION OF TREE FRUIT ARCHITECTURE

Ralph Scorza, USDA-ARS-AFRS, Kearneysville, WV 25430

The genetically available range in tree fruit architecture has not been fully utilized for tree fruit breeding or production. Higher planting densities, new training systems, high coats of pruning, the need to eliminate ladders in the orchard, and mechanized harvesting require a re-evaluation of tree architecture. Dwarf, semidwarf, columnar, and spur-type trees may be more efficient than standard tree forms, especially when combined with specific production systems. Studies of the growth of novel tree types and elucidation of the inheritance of growth habit components may allow breeders to combine canopy growth characteristics to produce trees tailored to evolving production systems.

369 (PS VII)

#### ROOTSTOCK INFLUENCE ON FRUIT TREE ARCHITECTURE

James N. Cummins, Dept. of Horticultural Sciences, N.Y. State Agricultural Experiment Station, Cornell University, Geneva, NY 14456.

Rootstock influence on tree architecture may be seen in a variety of expressions. Above ground effects include canopy volume and shape, crotch angles, branch display angles, relative distribution of long shoots and spurs, internode length, relative distribution of fruit buds and spurs, and trunk taper. Below the graft union, effects include relative distribution of fine vs. coarse roots, total root mass, and numbers, nature and distribution of burrknots. Many of these phenomena are indirect effects that stare from induction of fruiting by the rootstock, e.g., early fruit production induced by the rootstock will result in reduced canopy volume, reduced aboveground total mass, flatter branch display angles, and reduced root mass. The rootstock also plays a major role in the duration of shoot extension growth; by influencing the production of growth regulators in the shoot tip, the rootstock indirectly influences the inhibition of lateral buds and therefore the production of feathers.

798

#### SMALL FRUIT ARCHITECTURE

Adam Dale, Horticultural Research Institute of Ontario, Box 587, Simcoe, Ont. N3Y 4N5, Canada

Genetic variation in the architecture of berry crops will be reviewed. Examples will be given where changes in plant architecture have given increased yields, stabilized yields and improved fruit quality in strawberry, raspberry, highbush blueberry and currants.

Red raspberry will be emphasised as recent research on the architecture of the fruiting cane has enabled breeding strategies, based on plant architecture, to be developed.

## 89 WORKSHOP 10 (Abstr. 799-803)

799

#### BREEDING SWEETPOTATO FOR RESISTANCE TO MULTIPLE INSECT PESTS

Alfred Jones\*, U.S. Vegetable Laboratory, ARS, USDA, 2875 Savannah Highway, Charleston, SC 29414.

Sweetpotato [*Ipomoea batatas* (L.) Lam.] cultivars with high levels of resistance to root damaging insects have been developed through the collaborative efforts of a multi-

disciplinary research team. These resistances were combined with other traits necessary for a successful cultivar such as: disease resistances; high yield; long storage life; prolific sprout production; marketable root size, shape and skin at tributes; and culinary excellence. Adoption of quantitative genetic principles, development of a wide gene base, sequential selection schemes, use of effective selection criteria and appropriate susceptible standards contributed to the program's success. These achievements were made with, little prior knowledge about inheritance patterns, gene action, mechanisms of resistance or a complete knowledge of the insects concerned. The value of insect resistant cultivars has become better appreciated with the recent decrease in chemical alternatives.

800

#### IMPROVED HOST PLANT RESISTANCE BY MODIFICATION OF PLANT CHEMICAL CUES ASSOCIATED WITH *HELIOTHIS ZEA* HOST PLANT SELECTION FOR OVIPOSITION

John A. Juvik, Department of Horticulture, University of Illinois, 1103 West Dornier Drive, Urbana, IL 61801

*Heliothis zea* (Boddie) is one of agriculture's worst insect pests. Reduction in crop productivity and costs for insecticidal control of this cosmopolitan pest cost U.S. agriculture many millions of dollars annually. The sesquiterpenes (+)-E- $\alpha$ -santalol-12-ol and (+)-E- $\beta$ -bergamotol-12-ol acids isolated from hexane leaf extracts of the wild tomato species, *Lycopersicon hirsutum*, have been shown to attract and stimulate oviposition by female *H. zea*. Extracts from other host plants (tobacco, corn, and cotton) also possess attractant/oviposition stimulant activity to female *H. zea*. Studies are underway to assess the potential use of these and other phytochemicals for the control or monitoring of population levels of *H. zea* in tomato, corn and cotton fields.

The isolation and structural identification of insect pest oviposition stimulants in horticultural crop species can provide valuable information to plant breeders involved in developing cultivars with improved insect host plant resistance. This information could be used to develop cultivars lacking the chemical cues used by insects for host plant location and recognition. Risks of public exposure to toxic insecticides through consumption of agricultural produce and polluted ground water emphasize the critical need for the development of crop genotypes with improved host plant resistance as a supplementary method of insect pest management in agricultural ecosystems.

801

#### TRICHOME-MEDIATED RESISTANCE TO ARTHROPODS IN *LYCOPERSICON HIRSUTUM*

John C. Snyder, Department of Horticulture & Landscape Architecture, University of Kentucky, Lexington, KY 40546

Breeding for resistance to insects and other arthropod pests in vegetables has been a difficult endeavor. Greater public awareness of health and environmental issues requires that we as horticultural scientists reexamine why breeding for resistance has been difficult. The literature clearly suggests the potential for a genetic solution, and the literature also reveals some reasons why achievement of genetic resistance to arthropod pests has not been as successful as the achievement of resistance to pathogens. The thesis of my presentation is that the complexity of plant-arthropod interactions often prevents simple genetic approaches to breeding for resistance. Data using *Lycopersicon hirsutum* and its interaction with spider mites will provide examples of these complex interactions. *L. hirsutum* is a wild relative of *L. esculentum*, the common tomato, and is nearly immune to insect attack. However, there are few or no clear examples of this taxa contributing to the insect resistance of tomato. The complexity of the interaction between mites and trichomes on *L. hirsutum* will be highlighted as it pertains to environment and genetics of the plant, and the development of the arthropod.

802

#### BREEDING FOR RESISTANCE TO EUROPEAN CORN BORER IN SWEET CORN

David W. Davis\*, Elizabeth M. Lamb and Mary S. Joyce, Department of Horticultural Science, University of Minnesota, St. Paul, MN 55108

Insect resistance in vegetable crops carries a new urgency as insecticide availability and usage become more restricted. The European corn borer (ECB) long has been the most costly sweet corn pest in the northern states, with corn earworm (CEW) and southwestern stalk borer most serious farther south. Resistance to ECB and CEW, as developed by classical methods, will be discussed. Newer methods (such as RFLPs) should speed transfer of this resistance to commercial stocks, and also facilitate transfer of resistance from other species. Gene modification and endophyte exploitation are longer-term possibilities. Resistance must be free

from association with undesirable traits, such as long silk channel length ( $r = 0.3$  to  $0.4$ ), unless consumer and processor specifications change.

803

#### BREEDING SOUTHERNPEA AND TOMATO FOR RESISTANCE TO INSECT PESTS

Richard L. Fery\*, U. S. Vegetable Laboratory, ARS, USDA, 2875 Savannah Highway, Charleston, SC 29414

The use of multidisciplinary teams has been the key to making progress in the development of insect resistant southernpea [*Vigna unguiculata* (L.) Walp.] and tomato (*Lycopersicon esculentum* Mill.) cultivars; both the plant breeder and the entomologist have primary program responsibilities. The basic approach encompasses three separate but interrelated phases: 1) evaluation of germplasm collections to locate needed sources of resistances, 2) genetic studies to determine the inheritance of resistances, and 3) breeding programs to transfer resistance genes into adapted germplasm. The basic approach must usually be supplemented by concurrent research to, determine the nature and value of resistances and to develop evaluation procedures, selection criteria, and plant breeding methodologies. Selected examples from research projects on southernpea (resistances to cowpea curculio, southern green stinkbug, leaf footed bug, leaf miners, and thrips) and tomato (resistances to tomato fruitworm, tobacco hornworm, and Colorado potato beetle) will be used to illustrate approaches and methodologies.

## 102 WORKSHOP 12 (Abstr. 805-807)

805

#### USE OF ENVIRONMENTAL MANIPULATIONS IN SMALL FRUIT PRODUCTION

Marvin P. Pritts, Department of Fruit and Vegetable Science, Cornell University, Ithaca, NY 14853.

Manipulating light, temperature, moisture, and nutrients to favor plant growth and productivity is an important component of horticulture. The technology required to achieve such manipulation ranges from inexpensive, basic practices to elaborate, costly approaches involving the latest engineering advances. For example, pruning and mulching are relatively low-tech methods for improving light interception and soil moisture status in small fruit plantings. At the opposite extreme are glass houses with supplemental lighting, CO<sub>2</sub> enrichment, and nutrient film hydroponic systems. Of greatest value to small fruit growers, however, is technology that can be applied in field situations, such as the use of overhead irrigation for maintaining soil moisture status, frost protection, and evaporative cooling. One of the greatest challenges to small fruit growers and researchers is integrating new technology into production systems. The introduction of a new technique for environmental modification usually has indirect effects on other aspects of management, which may require additional technology to compensate for adverse changes while maintaining the favorable change. In addition, unique macro- and microclimates demand and market opportunities, specific solutions, and the result is a dynamic, diverse collage of production systems used by growers throughout the world.

806

#### OUTLOOK FOR MECHANIZATION IN SMALL FRUIT CROPS

Charles Mainland, Horticultural Science Dept., North Carolina State University, Raleigh, NC 27695

Mechanized harvest for processing markets has become commercially accepted for blackberries (*Rubus* sp.), highbush (*Vaccinium corymbosum*), lowbush (*V. angustifolium*) and rabbiteye (*V. ashei*), blueberries, cranberries (*V. macrocarpon*), grapes (*Vitis labruscana*, *V. vinifera*, *V. rotundifolia*, *V. sp.*), raspberries (*Rubus idaeus*) and to a lesser extent for strawberries (*Fragaria*  $\times$  *ananassa*). Fruit bruising during harvest and sorting often contributes to reduced "eye appeal" and keeping quality for fresh sales. Highbush and rabbiteye blueberries are successfully machine harvested for fresh markets, however, high temperature and rain will often make product quality unacceptable. Highbush blueberries grown in cool climates and rabbiteye blueberries with greater inherent resistance to bruising have most consistently given acceptable quality. Cultivar improvement and equipment that causes less bruising during harvest and sorting will be required for increased mechanization for fresh markets. Mechanical pruning of blackberries, blueberries, grapes and raspberries can reduce costs by up to 80%. The audience will be involved in discussion of advancements in mechanization techniques.

## POLARIZATION FOR LAND PREPARATION

Kim Patten, Washington State University, Long Beach, Washington, 98631

Soil polarization is a nonchemical pest management practice that can be used, under some circumstances, as an alternative to chemical fumigation for control of numerous weeds and soil pathogens. The efficacy of polarization is dependent on both biotic and abiotic factors. The uses and limitations of polarization for small fruit production will be discussed. Strategies for future research will be suggested.

## 103 WORKSHOP 13 (Abstr. 808-809)

## MINIMIZING ENVIRONMENTAL STRESS IN FIELD ESTABLISHMENT OF VEGETABLE CROPS

T.K. Hartz, Department of Botany and Plant Sciences, University of California, Riverside, CA 92521

Overcoming environmental stresses during seedling establishment is crucial to successful vegetable production. In the irrigated production areas of the West stress is most often related to unfavorable temperature, soil or water salinity, or poor soil structure; it is frequently difficult to separate the effects of these stresses since they may all be present to some significant degree. Growers use a variety of techniques to ameliorate these conditions. Advances in seed priming and coating have improved seedling establishment under unfavorable temperatures, particularly for lettuce. The use of sprinkler irrigation for stand establishment has become a widespread practice; sprinkling moderates soil temperature, minimizes salinity in the zone of germination, and reduces soil crusting. By modifying bed configuration growers have been able to increase soil temperature to stimulate germination. Modifying furrow irrigation patterns can create zones of lower salinity. Various chemical treatments have proven effective in reducing soil crusting. The use of transplants is expanding for many crops, both as a means to circumvent seedling establishment problems as well as a technique to obtain earliness.

## MINIMIZING ENVIRONMENTAL STRESS IN BEDDING PLANT AND GREENHOUSE PRODUCTION

Allan M. Armitage, Department of Horticulture, University of Georgia, Athens, GA 30602

Minimizing environmental stress in bedding plant and greenhouse and seedling development has occupied many researchers in academia and industry for many years. The dependence on single plant germination units (plugs) for bedding plant production and high value hybrid seed demand high rates of germination and successful seedling establishment. Pre-germinating or priming of seed is an important method of germination enhancement and methods and benefits of "priming" will be discussed. Environmental options to enhance seed germination of non-primed seed include control of vapor pressure deficit (VPD) and temperature.

Enhancement of seedling establishment through growth room and greenhouse technology includes the optimal use of CO<sub>2</sub>, temperature and light. Carbon dioxide fertilization on seedlings is receiving serious study and will be further elucidated.

## 122 WORKSHOP 14 (Abstr. 810-813)

## NATIVE SEEDS/SEARCH: BRIDGING IN SITU AND EX SITU CONSERVATION OF NATIVE SOUTHWESTERN CROPS

Gary Paul Nabhan\*, Mahina Drees and Kevin Dahl, Native Seeds/SEARCH, Tucson AZ 85719

The binational Southwest remains rich in native crop land races and crop wild relatives, despite numerous pressures favoring genetic erosion. Native

Seeds/SEARCH is promoting in situ conservation in traditional Indian fields and nearby wild habitats, but also maintains a gene bank as a back-up, to allow future reintroductions. Seeds are distributed to Native American communities for free, and their value is reinforced through a variety of educational materials and presentations. Our regional focus allows us to serve as an effective bridge between in situ and ex situ conservationists, between Indian and international organizations, and between tribes. Methods, ethics and accomplishments to date will be highlighted.

## HOW CURATORS OBTAIN INFORMATION ON GERMPLASM HELD OUTSIDE OF THE NATIONAL PLANT GERMPLASM SYSTEM

Kim Hummer\* USDA/ARS 33447 Peoria Road, Corvallis, OR 97333

The National Plant Germplasm System (NPGS) is a network of federal and state cooperative agencies which houses germplasm of economically important crops and their wild relatives. Curators are assigned to coordinate long term collections at facilities located throughout the country for optimum crop performance. Constant awareness of germplasm outside of the NPGS system will improve the scope and value of NPGS collections. This alternate source germplasm can reside in other national germplasm collections, in breeding and research collections, in botanical gardens and arboreta, and with private companies, organizations, or individuals. New plant explorations also continue to provide additional germplasm. Many organizations and individuals have begun compiling and publishing lists of germplasm sources. A summary of lists for temperate fruit and nut germplasm will be presented as an example. Compilations of this sort are extremely useful at the time of publishing but become outdated as listed sources change, or new sources are established. Periodic updating of published compilations are thus required. Contacts with Crop Advisory Committee members, plant researchers, and professional and amateur specialist organizations are also important sources of germplasm information.

## AN ALTERNATIVE APPROACH TO GERMPLASM PRESERVATION

*Kent Whealy, Director of Seed Savers Exchange, Rural Route 3, Box 239, Decorah, Iowa 52101.*

*Seed Savers Exchange (SSE), founded in 1975, is a grassroots network of nearly 1,000 amateur growers who are working together to save heirloom vegetables and fruit varieties from extinction. In 1986 SSE purchased a 140-acre farm near Decorah, Iowa. Major projects either in place or under development at Heritage Farm include large Preservation Gardens where the seeds of 1,200 rare vegetables are multiplied each summer. Historic Apple Orchard of 600 old-time varieties, and endangered breeds of livestock and poultry. This talk will focus on the history and development of SSE, differences in the user groups serviced by the National Plant Germplasm System (NPGS) and SSE, the differing problems faced by both systems, and specific ways that NPGS and SSE can compliment each other's efforts.*

## CROP GENETIC RESOURCE CONSERVATION AND THE THREAT POSED BY THE LOSS OF PUBLIC SECTOR PLANT BREEDING PROGRAMS

Laura C. Merrick, Department of Plant, Soil and Environmental Sciences, University of Maine, Orono, ME 04469

Collections of crop genetic resources have been assembled and evaluated as part of plant breeding efforts and in that capacity have served as the foundation for genetic improvement of crops. Most of these collections have been held at public sector institutions, including both federal and state agricultural experiment stations. However, recent changes have occurred in government agricultural research policies and funding structure which have lead to a decline in public sector breeding programs. Breeders retire and are not replaced or, for other reasons, programs are discontinued. The loss of the breeding programs may be adversely affecting the status of the associated germplasm, if no means are provided for continued conservation of the collections. The results of a nationwide survey to assess the number and status of crop germplasm collections associated with public sector plant breeding programs and the relationship of those collections to the National Plant Germplasm System will be discussed. Recommendations will be made in regard to coordination of activities to ensure conservation of the germplasm held in plant breeders' collections.

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## 123 WORKSHOP 15 (Abstr. 814-815)

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814

### RELATIVE GROWTH RATE: THE TWO-PHASE CURVE

Theodore M. DeJong, Department of Pomology, University of California, Davis CA 95616

The growth and development patterns of fruit have been studied for many years and it has become traditional to think of peaches as having a double sigmoid pattern with three main stages fruit growth. This concept is primarily based on analyses of fruit absolute growth rates. An alternative approach is to express growth on a relative growth rate (RGR) basis which is simply the weight increase per g of fruit weight per day. This analysis applied to dry-weight peach fruit growth results in a two-phase curve that is known mathematically as a Gompertz function. During the first growth phase the RGR decreases logarithmically and during the second phase the RGR remains relatively stable. Expressing fruit growth on a RGR basis is advantageous for fruit growth carbon budget modelling because RGR is directly related to respiration rates and for physiological studies because most analyses for physiologically active substances are expressed on a weight basis. There is obviously not only one "right" way to express fruit growth but it may be instructive to use the RGR approach particularly when studying factors that may be associated with "sink" activity.

815

### INTERPRETING FRUIT GROWTH: PROBLEMS AND POSSIBLE SOLUTIONS

Alan N. Lakso, Cornell University, NY State Agricultural Experiment Station, Geneva, NY 14456

Fruits of different species grow in different patterns (such as the "double sigmoid" of stone fruits and grapes or the apparent single sigmoid of apples), and each has periods of cell division followed by periods of only cell expansion. It should not be expected that one mathematical growth description would hold for all species, or even at all times of the season for one species. Perhaps hybrid growth models need to be developed, although specific questions asked about fruit growth may be satisfactorily answered with models of only parts of the fruit growth period of interest.

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## 145 WORKSHOP 19 (Abstr. 818-822)

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818

### COLLECTION OF PLANT VOLATILES USING HEADSPACE METHODS

T. R. Hamilton-Kemp\* and J. H. Loughrin, Dept. of Horticulture, University of Kentucky, Lexington, KY 40546  
R. A. Andersen, USDA-ARS, Dept. of Agronomy, University of Kentucky, Lexington, KY 40546

Two methods for collecting headspace vapors produced by plant samples are presented. The first involves entraining volatiles in a stream of air and trapping the entrained compounds on a porous polymer such as Tenax. The volatiles are recovered from the trap by solvent extraction or heat desorption and analysed by gas chromatography. A second method entails removing headspace vapor above plant material with a gas-tight syringe and injecting the sample directly into the gas chromatograph. An evaluation of the usefulness of these techniques will be presented.

819

### STUDY OF NON-ETHYLENE VOLATILE ORGANIC MOLECULES IN ASSESSING PHYSIOLOGICAL STATUS OF FRUITS

John K. Fellman\* Dept. Plant, Soil and Ent. Sciences, Univ. of Idaho, Moscow 83843 and James P. Mattheis, USDA/ARS Wenatchee WA 98801.

Developments in analytical technology, most notably high resolution fused silica open tubular (FSOT) gas chromatography-mass spectrometry (GC-MS), make it possible to investigate physiological

roles of volatile molecules occurring at low (ppb-ppm) concentrations. Use of headspace and purge-and-trap sampling coupled with cryofocusing injection techniques minimizes artifacts often created when more traditional methods of volatile molecule extraction are used. A challenging aspect of the work is development of appropriate delivery methods for internal standard quantitation of the molecules of interest. Apparently, biosynthesis of certain volatile substances is O<sub>2</sub> dependent and others are manufactured in response to a changing environment. FSOT GC-MS investigation revealed dramatic changes in content and quantity of 'Bisbee' apple headspace and purgable flesh volatiles during a 5-week harvest maturity period and 4 months of subsequent refrigerated storage. Other studies with apple mesocarp cultures and other fruits show interesting volatile molecule profiles in response to different treatments.

820

### CHANGES IN AROMA COMPOSITION DURING PEACH MATURATION

Robert J. Horvat\* and Glenn W. Chapman, Jr., R. B. Russell Agricultural Research Center, USDA, ARS, P. O. Box 5677, Athens, GA 30613.

Variations in the levels of volatile constituents during maturation of peaches were determined by means of capillary gas chromatography. C<sub>6</sub> aldehydes were the major volatile compounds isolated from immature fruit, however, as the fruit matured, levels of the C<sub>6</sub> aldehydes decreased. The final period of peach maturation (120 to 126 days after flowering) showed significant increases in benzaldehyde, linalool,  $\gamma$ - and  $\delta$ -decalactone;  $\gamma$ -decalactone being the principal volatile compound. The major volatiles, sucrose, quinic acid, and the malic/citric acid ratio, either singly or in combination, appear to be useful indices for estimating maturity of peaches.

821

### NON-ETHYLENE BIOLOGICALLY ACTIVE POSTHARVEST VOLATILES

Kays, Stanley J., Dept. of Horticulture, University of Georgia, Athens, GA 30602

While we tend to think of postharvest volatiles as nitrogen, oxygen, carbon dioxide and ethylene, harvested products are actually exposed to thousands of volatile compounds. These volatiles are derived from both organic and inorganic sources, evolving from storage room walls, insulation, wrapping materials, combusted products, plants, animals, and a myriad of other sources. Plants alone manufacture a diverse array of secondary metabolites (estimated to be as many as 400,000) of which many display some degree of volatility. We tend to be cognizant of volatiles when they represent distinct odors. A number of volatiles, however, have significant biological activity, and under appropriate conditions may effect postharvest quality. An overview of biologically active volatile compounds and their relation to postharvest quality will be presented.

822

### EFFECT OF STORAGE CONDITIONS ON NON-ETHYLENE VOLATILES IN ORANGES AND TOMATOES

Elizabeth A. Baldwin\* and Myrna O. Nisperos-Carriedo, USDA, ARS, SAA Citrus and Subtropical Products Laboratory, Winter Haven, FL 33883-1909

Edible lipid and composite films were tested for their ability to retain flavor volatiles in 'Pineapple' orange fruits stored at 21° using a headspace analysis technique. Volatiles, considered to be important to fresh orange flavor, were quantified and acetaldehyde, ethyl acetate, ethyl butyrate and methyl butyrate increased progressively during storage in coated fruits. Acetaldehyde increased by the second day of storage in uncoated fruits but declined thereafter. 'Sunny' tomato fruits were harvested at the green or breaker stage of maturity and ripened at 32.5, 21.0 and 12.9°C. Some fruit from the higher and lower storage temperatures were moved to 21° after one week. In most cases major or important flavor volatiles were highest in fruit transferred to or continuously stored at 21.0°C followed by 12.9 and 32.5°C. Fruit harvested at the breaker stage generally had higher volatile levels compared to those harvested green.

823

## EXTENSION MATERIALS ON COMPOSTING

B. Rosie Lerner, Purdue University, Department of Horticulture, West Lafayette, IN 47907

Each US state was surveyed to obtain a list of teaching materials and methods used to extend information on composting. Most states offer a bulletin on the subject and some have audio/visual materials. Methods of delivery include traditional lectures by staff and volunteers in most areas. Unique programs include the "Don't Bag It" program in Texas aimed at management of lawn clippings and the "Master Composers" in Washington State that develops volunteers trained specifically for composting education. A reference list of materials and programs submitted for this project will be available.

824

## COMPOST CONTENTS AND USES

Francis R. Gouin\*, Dept. of Horticulture, University of Maryland, College Park, MD 20742-5611

Compost varies according to content, composting procedures, age, storage conditions and particle size. Compost made mostly from wood products will have a much lower nutrient and soluble salt concentration than one made from leaves, grass clippings, sewage sludge, manures or food processing waste. Compost from efficiently managed systems optimizing microbial activity will tend to have higher soluble salt levels than compost from piles that are neglected and/or undisturbed.

Regardless of which organic materials used in making compost it will have a pH between 6.2 and 7.2 when ready for use. The effectiveness of compost as a soil amendment and in formulating potting mixes is dependent on particle sizes and soluble salt concentrations. Particles should not be recognizable and less than 2.5 cm in diameter for optimum plant response. Soluble salt concentrations of the compost will determine rates of application and fertilizer regime.

825

## YARD WASTE REDUCTION PROGRAMS

William E. Knoop\* and Phillip F. Colbaugh, Texas A&M University, Dallas, TX 75252

An urban educational program titled "Don't Bag It" having as its goal the reduction of the solid waste flow to landfills, was initiated in Ft. Worth the spring of 1988. The program, using media methods and volunteer demonstrators, teaches homeowners how to manage lawns without bagging grass clippings.

Very favorable program results have encouraged the spread of the program to 25 other Texas cities and the distribution of the program across the country:

826

## MASTER COMPOSTERS

Van M. Bobbitt, Washington State University Research and Extension Center, Puyallup, WA 98371-4998.

"Yard wastes comprise 25% of the average person's garbage," according to the King County (Washington) Solid Waste Division. In an effort to reduce the strain on landfills, municipalities are encouraging their citizens to compost yard wastes. Several communities in Washington State have organized Master Composter programs. Patterned after the successful Master Gardener program, volunteers receive intensive training in composting. In return, they deliver this information to the public through lectures, demonstrations, brochures, and composing demonstration gardens.

827

## OVERVIEW OF MUNICIPAL COMPOSTING

Richard Kashmanian, Office of Policy, Planning and Evaluation, US Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460

For an increasing number of communities across the U. S., their question is no longer, "should we compost?" Rather, their question has become, "what should we compost, and how?" This paper will present information on the experience of various communities and composting facilities in the collection, processing, and marketing of various compostable organic solid materials.

828

## COMPUTER-AIDED DESIGN AND VIDEO-DISC TECHNOLOGY IN LANDSCAPE DESIGN CLASSES

Mary Haque\*, Reginald Baumgardner\* and David Price, Department of Horticulture, Clemson University, Clemson SC 29634-0375

Several forms of computer technology have been successfully integrated into classes at Clemson University using Mac II computers and MacDraft software. Beginning students are producing professional looking plans with consistent line quality and individual graphic style. Plant selection for designs has been augmented through plant images contained on two videodiscs; *Woody Landscape Plants of the Temperate United States* and *Clemson University Video Encyclopedia of Herbaceous Ornamental*. Access is accomplished via MacRAPID© CU, a Hypercard© stack that also provides a linkage to MacCAPS© Terisan. With these two programs, the user can quickly select and view, based on specific criteria, plants suitable for a given landscape.

## 37 COLLOQUIUM I (Abstr. 831-834)

831

## ESTABLISHMENT OF COMPUTER-BASED ENVIRONMENTAL CONTROLS

Steven H. Schwartzkopf, Lockheed Missiles & Space Co., Inc. Sunnyvale, CA 94088-3504

The use of computerized environmental control systems for greenhouses and plant growth chambers is increasing in frequency. Computerized systems provide the potential for more accurate environmental control, while at the same time allowing changes to be made more easily than with hard-wired mechanical control systems. The ease of changing allows switching sensor types, relocating sensors and resetting control parameters without significantly affecting the overall system design. Another advantage of computerized control systems is that they provide a method for recording environmental data as they simultaneously implement their programmed control algorithms. This data can subsequently be transferred to other computers for further processing and analysis. Computerized controls also support the possibility of implementing environmental control based on either mathematical models which simulate plant growth, or on actual monitored plant performance data such as nutrient uptake or leaf temperature. This paper discusses in detail these and other advantages of using computerized environmental control systems, as well as describing the problems and disadvantages associated with their implementation and use.

832

## CONTROL AND MEASUREMENT OF PLANT FUNCTIONS BY COMPUTER-BASED ENVIRONMENTAL MANIPULATION

Craig McFarlane\* and Thomas Pfleeger, US Environmental Protection Agency, 200 S.W. 35th St., Corvallis, OR. 97333

Chambers were developed to study the uptake, accumulation and phytotoxicity of environmental pollutants. Each is connected to the computer and other support facilities by quick connects which allow the laboratory to be configured in various ways depending on experimental design. Each chamber consists of two isolation compartments connected only by plant stems. Electronic instruments are used to monitor key physiological processes of both the roots and shoots during the course of plant exposure. The computer controls the exposure conditions (i.e. day length, temperature, nutrient pH, CO<sub>2</sub> concentration, etc.) as well as continuously collects information about plant responses (i.e. photosynthetic and transpiration rates). Photosynthesis, transpiration, and mineral nutrient uptake can be individually controlled by manipulating the environment and thus allowing their study in combination with additional stressors. The computer used to accomplish these tasks will be discussed along with other examples of computer use for plant manipulation.

# PLANT GROWTH MODELS, THE FOUNDATION OF ENVIRONMENTAL CONTROL STRATEGIES.

Royal D. Heins, Department of Horticulture, Michigan State University, East Lansing, MI 48824

Environmental control computers allow regulation of greenhouse environments based on some model driven factor or factors other than fixed heating and cooling setpoints. A quantitative understanding of how environmental factors influence rate of plant development, flower initiation, and plant morphology is necessary to develop models for environmental control. The major limitation to the use of models for greenhouse climate and crop control is the lack of quantitative models. Examples of model development for environmental control will be discussed.

# MANAGING ENVIRONMENT TO OPTIMIZE PRODUCTION AND MINIMIZE COSTS

Maynard E. Bates, Bionetics Corporation, NASA/Ames Research Center, Moffett Field, CA 94035-5020

Increased production and reduced costs are goals of all plant growers. As a rule, introduction of computer-based control of the plant environment in a well-designed greenhouse will result in yield increases of thirty percent (30%) over other control techniques. A simple model will show how these changes impact profitability.

New technologies in sensors, interfaces, computers, software, and plant growth knowledge are being applied to management of the crop environment. Examples of direct canopy temperature measurement, on-line plant weight measurement, integration and control of photosynthetic photon flux, and nutrition control will be presented. Integrated process control is replacing setpoint maintenance. Models are being developed for incorporation into environmental control systems. Examples for solar irradiance and crop growth will be demonstrated.

Ultimately expert systems based on artificial intelligence technology will manage crop production in controlled environments. These systems will incorporate information on crop genome, local climate, cultural practices, pests and diseases, economics, and markets, in addition to environmental control. A possible configuration of the hardware and software for such a system will be discussed.

School District asked the California Farm Bureau to help develop ag education activities and materials for all grade levels. There is now an AITC effort in every state. Each state approaches Ag in the Classroom from the basis of its own needs and resources. The most successful state programs are a result of cooperation among agriculture, education, volunteers and government. The USDA serves as the communication link among states.

Major objectives of AITC include: 1) contribute to a population with a greater understanding of agriculture's importance to our economy and society, 2) promote awareness of career opportunities in agriculture. Activities and materials are offered in: Teacher Training, Student Program, Resource Materials and Special Programs.

When given the opportunity, educators realize the importance of agriculture to them and their students. They have found that infusing ag information into the lessons they teach adds an exciting dimension to classroom activities.

# USING SCIENCE/TECHNOLOGY/SOCIETY ISSUES TO ACHIEVE SCIENTIFIC LITERACY

Gordon Johnson, Department of Physics, Northern Arizona University, Flagstaff, AZ 86011

Enabling citizens to have meaningful participation in public discussions of issues interfacing science/technology and society (STS) has long been a goal of science education. Involving students in investigating issues may be the most effective way of insuring continued involvement as adults. Global, national, and local horticultural issues can provide concepts for learning relevant science concepts, process skills, and other outcomes. Selecting and designing investigations of horticulture issues include input from both students and teacher. Questions that get at scientific concepts, technological implications, and societal concerns related to the issue give direction and scope to the study. The questions and responses can be student initiated with teacher guidance. Students gain experience in examining and discussing societal issues, recognizing interdependence of STS, and learning relevant science as well. As a result, students perceive horticulture as having relevance to their concerns rather than as an isolated discipline.

## 114 COLLOQUIUM III (Abstr. 835-837)

# SCIENCE CURRICULA IN THE PUBLIC SCHOOLS: PRIMARY AND SECONDARY

Anton E. Lawson, Department of Zoology, Arizona State University, Tempe, AZ 85287-1501

According to recent surveys 80% of the primary, 90% of intermediate grade teachers, and 50% of all teachers base their instruction upon a single textbook; almost all questions arise from information in the textbook and most center on terminology; the common pattern of science instruction is assign, recite, test, and discuss the test, all based upon the textbook. The result of such instruction is that students demonstrate poor science achievement (both in terms of discipline specific knowledge and in terms of an ability to think and act in a scientific way) and poor attitudes towards science. In contrast, a number of excellent science K-12 programs have been developed in this country during the past 10-20 years and when used properly, achievement and attitude gains are considerable. Regrettably our system of district level control makes implementation of these superior programs difficult.

# WHAT IS AGRICULTURE IN THE CLASSROOM?

Mark P. Linder, California Foundation for Agriculture in the Classroom, 1601 Exposition Blvd. FBI 3, Sacramento, CA 95815

Agriculture in the Classroom has become a major, positive force addressing the ag literacy challenge. In California, Ag in the Classroom began in 1980 when the San Francisco

## 172 COLLOQUIUM IV (Abstr. 839-845)

# WATER-USE TRENDS AND DISTRIBUTION IN THE U. S., 1950-85

Wayne Solley, U.S. Geological Survey, Reston, VA 22092

Water use in the United States increased from 1950 to 1980 and decreased from 1980 to 1985, on the basis of estimates compiled at 5-year intervals by the U.S. Geological Survey. Total withdrawals of freshwater and saline water during 1985 were 1,510 million cubic meters per day, a rate more than double that estimated for 1950 and 10 percent less than that estimated for 1980. For most categories, the rate of increase in water use declined from 1970 to 1975 and from 1975 to 1980. Withdrawals for thermoelectric-power generation and irrigation, the two largest categories of use, were 13 and 6 percent, respectively, less during 1985 than during 1980. The combined total for industrial, commercial, and mining water use during 1985 was 25 percent less than during 1980--the lowest combined estimate for these categories since the compilations began in 1950. The decrease in water use during 1985 compared to 1980 can be attributed to the following important factors:

1) Streamflow generally was more plentiful during 1985 than during 1980 because of more rainfall; this reduced the dependence on ground water in many areas and the need to irrigate in some areas.

2) The economic slowdown, improved plant efficiencies, depressed commodity prices, and new technologies that require less water decreased the requirements for industrial and irrigation water.

3) Enhanced awareness by the general public to water resources and conservation programs in many States probably reduced water demands.



# INTERACTION OF WATER SUPPLY PLANNING AND ENVIRONMENTAL PROTECTION

Daniel F. Luecke, Environmental Defense Fund, Boulder, CO 80302

Water resource development, particularly dam construction and inter basin diversions, can cause substantial environmental damage. Minimizing future damage can best be accomplished by using existing systems more efficiently, thus, reducing the need for supply augmentation. In the U.S., agriculture accounts for 83% of the annual total water consumption. The municipal and industrial sectors account for the remaining use. These shares are inversely related to economic value; agricultural water is worth between \$30 and \$75 per acre-foot in most applications while water in the municipal sector may be worth as much as \$300 to \$500 per acre-foot. The system inefficiencies implied by the sectors' use and relative economic values make it clear that water supply planning can be improved. If cost-effectiveness were the criterion against which water supply options and alternatives were assessed, system management and end-use efficiency would replace supply augmentation. Institutional, not technical, constraints prevent the adoption of the more efficient options. Were these constraints relaxed, the monetary and environmental savings would be substantial.

# REDUCING WATER USE DURING CUT FOLIAGE PRODUCTION

Robert H. Stamps, University of Florida, Institute of Food and Agricultural Sciences, Central Florida Research and Education Center, 2807 Binion Road, Apopka, Florida 32703

As the area devoted to cut foliage production has increased and residential development has encroached upon these agricultural areas, conflicts between growers and homeowners have increased. Withdrawals of water for cold protection produce severe reductions of local artesian levels which render domestic wells inoperative and lowered lake levels have made some boat docks useless. Overhead sprinkler irrigation has been used for irrigation and cold protection of cut foliage crops since the 1960's. Using water application rates of about 0.84 cm-hr<sup>-1</sup> growers were able to reliably supply product on a year-round basis. Water management district developed regulations mandate that certain water saving methods be implemented prior to the issuance or renewal of consumptive use permits and limit water application rates for cold protection to 0.56 cm-hr<sup>-1</sup> under certain circumstances. Research on irrigation scheduling and various cold protection strategies have and are being conducted to allow further reductions in water use during the production of cut foliage crops.

# RESEARCH ON TURFGRASS WATER USE IN ARIZONA

Charles F. Mancino\*, Department of Plant Sciences, University of Arizona, Tucson, AZ 85721

Arizona's golf and sod industry generates \$280 M year<sup>-1</sup> in revenue and surpasses the vegetable, cotton and dairy industries. Despite the economic worth of turf, a need still exists to conserve the limited supply of potable water in this harsh Sonoran Desert environment. Mandatory water conservation programs have been developed for many sectors of the Arizona economy. To meet this challenge, the turfgrass industry and government bodies have begun to contribute to the development of research programs which reduce turfgrass water requirements and dependence upon potable water. Current research includes a) determining the minimum water requirements of higher quality turf under conditions of high temperatures and vapor pressure deficits; b) the turfgrass potential of grasses with lower water requirements than bermudagrass; c) the development of a statewide weather station network to predict daily turfgrass water use; and d) determine management strategies for turfgrass irrigated with wastewater effluent. The overall goal of these programs is to produce high quality and functional turf with 20 to 50 percent less water.

# INNOVATIVE IRRIGATION TECHNIQUES IN NURSERY PRODUCTION TO REDUCE WATER USAGE

John Kabashima, University of California Cooperative Extension, 1000 S. Harbor Blvd, Anaheim, CA 92805

Several production nurseries were surveyed about techniques used to reduce water usage and runoff. The nurseries surveyed used from 400,000 gallons of water per day to 5,000,000 gallons of water per day during peak usage. Water availability and the potential for nitrate runoff from large production nurseries to contaminate the environment have resulted in requirements by regulatory agencies to decrease water usage and runoff. Nurseries have complied by using techniques such as drip irrigation, subirrigation, pulsing, recycling, and computer controlled irrigation systems. The use of techniques such as recycling and "better management practices" have resulted in significant decreases (approximately 30%) in water usage.

# LONG ISLAND VEGETABLE PRODUCTION: RESULTS OF RESEARCH AND IMPLEMENTATION PROGRAMS TO REDUCE WATER USAGE

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There are approximately 17,000 acres of fresh market vegetables and potatoes being produced on Long Island where irrigation is a routine agricultural production practice. Irrigation water is obtained from individual wells which pump water from an extensive underground aquifer. Although the quantity of water available for irrigation is not limited at present and will not be in the foreseeable future, the combination of agricultural practices, sandy soils and low soil pH's have had an impact on water quality. Certain pesticides move easily through the porous Long Island soils and are not quickly broken down at the naturally low pH levels of these soils. The use of Temik (aldicarb) for potato production resulted in ground water contamination with this chemical and spurred action by horticultural researchers and county and state agencies to define the scope of, and provide a potential solution for, contamination of Long Islands ground water. Thus, considerable effort has been expended on research and implementation programs to prevent ground water contamination with agricultural chemicals. Much of this effort has involved attempts to alter cultural practices, such as irrigation and pesticide application methods in order to decrease the potential for leaching of contaminants into the ground water. In addition, alternate crops have been considered which may require less irrigation and fewer pesticides than those traditionally grown. Specific research projects and government agency policies pertaining to agricultural water usage on Long Island will be discussed.

# IMPLEMENTATION OF MICROIRRIGATION FOR CITRUS PRODUCTION IN FLORIDA

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The use of microirrigation in Florida citrus production has increased rapidly in recent years. Most new groves are now being developed with microspray or drip irrigation. Many existing sprinkler and seepage (subirrigation) systems have also been converted to micro irrigation. Although water management districts have encouraged the use of micro irrigation for water conservation, research results which solved problems with the practical implementation of this technology and which demonstrated economic incentives are primarily responsible for its popularity in Florida citrus production. Research programs have (1) developed management techniques to eliminate emitter clogging, (2) demonstrated the effective use of microspray systems for freeze protection, (3) increased young tree growth with respect to conventional irrigation methods, (4) demonstrated the cost-effectiveness of microirrigation, and (5) developed management techniques for efficient use of water and nutrients in fruit production.