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**60 ORAL SESSION 11 (Abstr. 501–508)**  
**Fruits/Nuts: Nutrition**  
**Monday, 24 July, 4:00–6:00 p.m**

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501

**Summary of Leaf Potassium Status in 'French' Prune Suggests Overfertilization**

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Prune (*Prunus domestica*) producers have an increased incentive to produce larger fruit. Potassium is thought to be critical in prune production and the fruit utilize large amounts of K. Growers have been fertilizing heavily with K to maximize fruit size. We conducted a survey of 16 'French' prune orchards in 1998 and 1999 growing seasons. Low ( $\approx 1.0\%$  mid-July) leaf K concentration is associated with leaf chlorosis, early leaf drop and shoot dieback, with symptoms pronounced in the upper canopy, particularly with heavy cropping. The survey orchards were chosen to represent a range of leaf K within and among orchards, and among counties. At harvest, fruit drying ratio, dry yield per tree, and dried fruit size were determined in order to develop relationships between fruit quality and yield, and leaf K over the growing season. To date we have determined the following: 1) spring (May 1998 and April–May 1999) leaf K concentration is correlated with mid-summer (mid-July 1998) and early summer (late June 1999) leaf K concentration, respectively; 2) mid-April to mid-May leaf K concentration is being maintained by growers due to thinning and fertilizing, and to light cropping in 1998, at adequate to above adequate levels (2%) that increase through the growing season; 3) no beneficial relationship between fruit size, drying ratio or dry yield has been found with spring or summer (June or mid-July) leaf K concentration above 2%, either when evaluating all surveyed orchards together or as individual orchards.

502

**Reassessment of Leaf Potassium Critical Values in Almond**

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Almond [*Prunus dulcis* (Mill.) D.A. Webb] yields have increased substantially since the 1961 publication of the Univ. of California (UC) guidelines for leaf potassium (K). Numerous growers and reputable analytical laboratories are concerned that the recommendations for leaf K are inadequate. A highly productive almond orchard with low leaf K was selected to reassess the leaf K critical value of 1.1% to 1.4% and determine the relative sensitivity of various yield determinants to inadequate K availability. Baseline yields for 100 individual trees were measured in 1998 and four rates of potassium sulfate were applied under drip irrigation emitters to establish a range of July leaf K concentrations between 0.5% and 2.1%. No relationship was observed between leaf K and post-treatment yield measurements made in 1999. We also monitored individual limb units on trees from the treatment extremes for effects of low K availability on flower number, percentage fruit set, fruit size, spur mortality, and vegetative growth (potential fruiting sites in subsequent years). Those measurements indicated that although current-year yield determinants (percentage fruit set and fruit size) were not influenced by K deficiency, components of future yield were impacted negatively by low K availability: mortality of existing fruiting spurs was increased by K deficiency and growth of fruiting wood was reduced.

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**Effect of Source and Timing of Potassium Fertilizer on 'Empire' Apple Tree Growth, Yield, and Fruit Quality**

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A field experiment was established in 1993 in a 3-year-old 'Empire'/M.9 apple orchard. An incomplete factorial treatment design compared nitrogen only fertili-

zation with nitrogen plus potassium fertilizer applied either on the ground with and without trickle irrigation or through the trickle irrigation system. Timing of potassium fertigation treatments compared season-long K fertigation to early season or late-season K fertigation. Results of main effects showed that K fertilization reduced trunk cross-sectional area increase, but increased yield, fruit size, and fruit red color. There was no benefit of fertigation compared to ground application of fertilizers plus trickle irrigation. There was no effect of source of K fertilizer (KCl vs KNO<sub>3</sub>) on tree growth, yield, fruit size, or color. Time of K fertigation showed that late-season K fertigation resulted in greater trunk cross-sectional area increase compared to early season fertigation or season-long fertigation. Fruit size was greatest when K fertigation was done in the early season. There was no effect of time of fertigation on yield or fruit red color. Potassium fertilization increased leaf K levels and reduced leaf Mg levels. Time of fertigation did not affect leaf K levels, but early season fertigation resulted in higher leaf N levels.

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**Urea Uptake and Nitrogen Mobilization by Apple Leaves in Relation to Tree Nitrogen Status in the Fall**

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Bench-grafted Fuji/M26 trees were fertigated with seven nitrogen concentrations (0, 2.5, 5.0, 7.5, 10, 15, and 20 mm) by using a modified Hoagland solution from 30 June to 1 Sept. In Mid-October, plants in each N treatment were divided into three groups. One group was destructively sampled to determine background tree N status before foliar urea application. The second group was painted with 3% <sup>15</sup>N-urea solution twice at weekly interval on both sides of all leaves while the third group was left as controls. All the fallen leaves from both the <sup>15</sup>N-treated and control trees were collected during the leaf senescence process and the trees were harvested after natural leaf fall. Nitrogen fertigation resulted in a wide range of tree N status in the fall. The percentage of whole tree N partitioned into the foliage in the fall increased linearly with increasing leaf N content up to 2.2 g·m<sup>-2</sup>, reaching a plateau of 50% to 55% with further rise in leaf N. <sup>15</sup>N uptake and mobilization per unit leaf area and the percentage of <sup>15</sup>N mobilized from leaves decreased with increasing leaf N content. Of the <sup>15</sup>N mobilized back to the tree, the percentage of <sup>15</sup>N partitioned into the root system decreased with increasing tree N status. Foliar <sup>15</sup>N-urea application reduced the mobilization of existing N in the leaves regardless of leaf N status. More <sup>15</sup>N was mobilized on a leaf area basis than that from existing N in the leaves with the low N trees showing the largest difference. On a whole-tree basis, the increase in the amount of reserve N caused by foliar urea treatment was similar. We conclude that low N trees are more effective in utilizing N from foliar urea than high N trees in the fall.

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**Sensitivity of Pear and Apple Plants to Urea Fertilizers**

*Shufu Dong<sup>\*</sup>, Lailiang Cheng, Guihong Bi, and Leslie H. Fuchigami*; Department of Horticulture, Oregon State University, Corvallis, OR 97331

'Gala'/M26 apple and 'Bartlett'/OH97 pear trees growing in containers were treated with either 0, 1, 5, 10, 20, or 30g of urea dissolved in 150 mL of distilled water on 7 Sept. 1999. Two weeks after application, a soil sample from each container was analyzed for NH<sub>4</sub><sup>+</sup> and NO<sub>3</sub><sup>-</sup>. One day after treatment, the leaves of the apple trees treated with either 20 or 30 g urea wilted and curled and none of the other apple treatments were affected. However, 20 days later, new lateral and terminal buds broke to grow from these two treatments. In contrast, the pear trees showed signs of wilting and leaf necrosis in the 5, 10, 20, and 30 g urea treatments about 6 days after application. Twenty days after treatment, the leaves from the two highest treatments were completely necrotic and remained attached to the trees, while the leaves of 5- and 10-g treatments were partially necrotic and began defoliating. None of the pear trees produced any new lateral or terminal growth. Soil test showed that NH<sub>4</sub><sup>+</sup> contents of the soils were 54.9, 104.2, 356.9, 884.28, 1154.9, and 1225.2 mg/kg for 'Bartlett'/OH97, and 30.2, 62.9, 359.0, 235.1, 529.9, and 499.0 mg/kg for 'Gala'/M26 and NO<sub>3</sub><sup>-</sup> contents of the soils were 40.5, 62.4, 211.0, 129.8, 54.5, and 39.5 mg/kg for 'Bartlett'/OH97, and 37.6, 42.0, 178.7, 138.2, 186.2, and 142.1 mg/kg for 'Gala'/M26 treated with 0, 1, 5, 10, 20, and 30 g urea, respectively.

### Air Temperature, Humidity, Leaf Age, and Solution pH Affect Penetration of Urea Through Citrus Leaf Cuticles

Vladimir Orbovic<sup>1</sup>, Diann Achor<sup>1</sup>, Peter Petracek<sup>2</sup>, and James P. Syvertsen<sup>1</sup>;  
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We examined the effects of air temperature, relative humidity (RH), leaf age, and solution pH on penetration of urea through isolated cuticles of citrus leaves. Intact cuticles were obtained from adaxial surfaces of different aged grapefruit leaves. A finite dose diffusion system was used to follow movement of <sup>14</sup>C-labeled-urea from solution droplets across cuticles throughout a 4-day period. The rate of urea penetration increased as temperature increased from 19 °C to 28 °C, but penetration was not further increased at 38 °C. Increasing RH increased droplet drying time and urea penetration at both 28 °C and 38 °C. Cuticle thickness, weight per area, and the contact angle of urea solution droplets increased as leaves aged. Cuticular permeability to urea decreased as leaf age increased from 3 weeks to 7 weeks, but permeability increased in cuticles from leaves older than 9 weeks. Contact angles decreased with increased urea solution concentration on six 7-week-old leaf surfaces, but solution concentration had no effect on contact angle on cuticles from younger and older leaves. Reducing pH of urea solution from pH 8 to pH 4 accelerated the loss of urea from breakdown, possibly due to hydrolysis.

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### Nitrogen Uptake Dynamics of Citrus Seedlings

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Improving our understanding of processes that control and limit nitrogen uptake by citrus can provide a scientific basis for enhancing nitrogen fertilizer use efficiency. Nitrogen uptake dynamics of two rootstock seedlings will be compared to those of young budded trees. Three-month old Swingle citrumelo [*Citrus paradisi* Macf. x *Poncirus trifoliata* (L.) Raf.] and Volkamer lemon (*C. volkameriana* Ten. & Pasq.) trees were planted in PVC columns filled with a Candler fine sand. Field experiments were conducted using 4-year-old 'Hamlin' orange trees [*Citrus sinensis* (L.) Osb.] grafted on 'Carrizo' [*C. sinensis* x *Poncirus trifoliata* (L.) Raf.] or on Swingle citrumelo. Trees were either grown in solution culture using 120-L PVC containers or in 900-L PVC tubs filled with a Candler fine sand. Additional trees were planted in the field during Spring 1998. Two lateral roots per tree were trained to grow in slanted, partly buried, 20-L PVC columns filled with a Candler fine sand. Nitrogen uptake from the soil was determined by comparing the residual N extracted by intensive leaching from planted units with that of non-planted (reference) units. With the application of dilute N solutions (7 mg N/L), plants reduced N concentrations to near-zero N concentrations within days. Applying N at higher concentrations (70 or 210 mg N/L) resulted in higher initial uptake rates, increased residual soil N levels, and reduced nitrogen uptake efficiency. Contributions of passive uptake to total nitrogen uptake ranged from less than 5% at soil solution concentrations around 3 ppm N to 20% to 30% at concentrations of 60 ppm N.

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### Studies on the Effects of Zinc Supply on Growth, Development, and Nutrient Uptake of Pecan Seedlings from Different Seedstocks

Tehryung Kim\*, Harry A. Mills, and Hazel Y. Wetzstein; Department of Horticulture, University of Georgia, Athens, GA 30605

Zinc deficiency is a nutrient disorder that is observed in pecan production areas. In the field it is characterized by a rosette shoot habit and interveinal leaf chlorosis. Up to now, the induction of zinc deficiency has not been accomplishable in the field or greenhouse. Thus any critical evaluations of effects of zinc nutrition on tree growth and development have been lacking. A hydroponic culture system was developed where zinc deficiency was induced. Seedstocks collected from 'Stuart', 'Curtis', and 'Wichita' trees were grown with and without zinc supply. Biomass, leaf area, node number, and visual symptoms were assessed. Foliar deficiency symptoms were rated 4 and structural evaluations were conducted using light and electron microscopy. Significant differences in visual symptoms were observed between treatments and among cultivars. Leaf area significantly decreased in 'Stuart' and 'Curtis' under zinc deficient conditions. Zinc had no significant effect on biomass and internodal length. Foliar nutrient contents were

compared between cultivars. Our data suggest that genotypic differences in sensitivity to zinc deficiency exists and improving pecan production through genetic selection for zinc efficiency appears promising.

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## 61 ORAL SESSION 12 (Abstr. 428–435) Woody Ornamentals/Landscape/Turf: Physiology & Nutrition Monday, 24 July, 8:00–10:00 a.m

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### Defoliation Affects Return Bloom, Fruit Set, and Fruit Quality of Three Apple Cultivars

David E. Davis<sup>1</sup>, John A. Barden<sup>1</sup>, and Ross E. Byers<sup>2</sup>; <sup>1</sup>Dept. of Horticulture, Virginia Tech, Blacksburg, VA 24061; <sup>2</sup>Virginia Tech Agr. Res. & Ext. Ctr., 595 Laurel Grove Rd., Winchester, VA 22602

In 1997 and 1998, we determined the effects of defoliation on return bloom and fruit set following a light cropping year. In one study, 'Braeburn' trees were hand-thinned to a crop density (CD) of 3 fruit/cm<sup>2</sup> trunk cross sectional area (TCSA) in late May 1997, and then either completely defoliated or half of the tree defoliated by hand on one of five dates between June and Sept. 1997. Compared to a nondefoliated control, both whole and half-tree defoliation on all dates reduced fruit count and yield efficiency (kilograms per square centimeter of TCSA) and affected fruit weight, starch, firmness, and soluble solids in 1997. In 1998, return bloom and fruit set were reduced by most 1997 defoliation treatments. Compared to other dates, defoliation on 3 July caused the greatest reduction in return bloom in both whole and half-defoliated trees. In another study, 'Braeburn' trees were hand-thinned to a CD of 5 in late May 1998; complete defoliation by hand on 1, 15, or 29 July reduced return bloom and fruit set in 1999; the 1 July treatment resulted in zero return bloom. 'Golden Delicious' and 'York' trees were thinned to a CD of 3 in late May 1998 and were hand-defoliated on 21 July or 12 August by removing every other leaf or removing three of every four leaves over the entire tree. In 1999, return bloom and spur and lateral fruit set were reduced by all defoliation treatments. Fruit set was most reduced by the 12 Aug. treatment. Fruit set for 'York' was lower than for 'Golden Delicious' in all cases.

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### Impact of a Reduced Fungicide Program on 'Liberty' Apple Tree Vigor, Productivity, and Fruit Quality

L.P. Berkett, M.E. Garcia\*, J. Clements, and G. Neff; Plant and Soil Science Dept., Hills Bldg., Univ. of Vermont, Burlington, VT 05405

Apple scab, a fungal disease caused by *Venturia inaequalis*, is considered the most important disease of apple worldwide. The disease can be devastating, causing reduction in yield or making the apples unfit for the market. Currently, the production of marketable fruit from scab susceptible cultivars depends on the repeated applications of fungicides. Scab-resistant apple cultivars, which are genetically immune to apple scab, can offer a biological alternative to fungicide use. 'Liberty,' was bred for immunity to apple scab; however, it is not immune to other apple diseases and pests. Research has been conducted during a 3-year project (1996–1998) to determine whether reduced fungicide programs adversely affect overall tree vigor, productivity, and fruit quality. Data collected include tree vigor (TCSA and time of leaf abscission), tree productivity (YE), and fruit quality (fruit firmness and disorders during storage). Results indicate no significant differences between the two treatments (reduced fungicide and no fungicide application) in most of the parameters measured. Based on fruit that were harvested and graded to commercial standards, the estimated gross monetary value of the crop does not show difference between treatments. These results could translate into an economic advantage for growers when one factors in the savings in fungicide purchases. In addition, there are also health and environmental advantages to reduced fungicide usage.

### Diagnosis and Management Strategies for Soilborne Apple Replant Problems in New York Orchards

Ian A. Merwin\*, Terence L. Robinson, Steven A. Hoying, and Rachel R. Byard; Depts. of Fruit & Vegetable Science, and Horticultural Sciences, Cornell Univ., Ithaca, NY 14853

We are evaluating the severity of apple replant disease (ARD)-characterized by stunted tree growth in replanted orchards, attributed to root pathogens and/or edaphic conditions—and testing preplant soil treatments for control of this widespread problem. Soil samples were collected during 1996–98 at 17 orchards in New York's major fruit growing regions and plant-parasitic nematodes and nutrient availability were quantified. Apple seedlings and potted trees on M.9 rootstocks were grown in fumigated and non-fumigated soil samples as a diagnostic bioassay for ARD severity. Factorial combinations of metam sodium, consecutive cover crops of *Brassica juncea* 'Forge' and *Sorghum sudanense* 'Trudan 8', and fertilizer/lime amendments were applied as preplant treatments at each orchard, 9 to 12 months before trees were replanted. Diagnostic bioassays indicated severe ARD at more than half the sites, and nematodes were not a major factor. Responses to preplant soil treatments were highly variable across the 17 farms. The best tree growth and yields followed preplant metam sodium at some sites, *Brassica juncea* and *Sorghum sudanense* at others, or fertilizer amendments at a few others. Tree responses to combined preplant soil treatments were often additive, and greater at irrigated sites. Comparisons of preplant diagnostic bioassay results with subsequent tree responses to metam sodium at the 17 orchards indicated that diagnostic tests predicted from 7% to 75% of tree growth response to soil fumigation, varying substantially across years and sites. It appeared that ARD was variable and site specific in New York orchards, and could not be controlled effectively with a uniform preplant soil treatment across our major fruit-growing regions.

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### Comparison of Freezing Protectant Sprays Applied to Avocado Trees

Robert J. McNeil\*, David O. Medders, and Ramiro Guzman; Crop Science Department, California Polytechnic State University, San Luis Obispo, CA 93407

Six freezing protectant products were sprayed at label rates on 1-year-old 'Hass' avocado trees. Control trees were sprayed with water. Treatments were applied three times at monthly intervals, 20 Dec., 20 Jan., and 20 Feb. The products tested were Copper Count-N, Champ, Frostguard, Frost Shield, Anti Stress 550, and Insulate. Two separate orchard areas were treated, one with additional freezing protection by a wind machine and the other with no wind machine. Freezing temperatures and subsequent leaf damage occurred on 4 Jan., which was 2 weeks after the first treatment. The wind machine protected area experienced 2 h at or below 30 °F, with a minimum temperature of 29 °F, while the area without a wind machine experienced 5.5 h at or below 30 °F with a minimum temperature of 27.9 °F. One hundred mature leaves per tree were rated as to any freezing damage, slight damage (1% to 33%), moderate damage (33% to 66%), or severe damage (66% to 100%). All six freezing protectant products consistently reduced the percentage of leaves with freezing damage below that of the water-treated control trees, except in one instance, for all four categories of leaf freezing damage evaluated in both orchard areas—that with and that without a wind machine. Damage was reduced by approximately half for some of the treatments as compared to control trees. Data for some or all freezing protectant products was statistically different (less) than the control in two freezing damage categories (slight and moderate) in the area without a wind machine, however, data was not statistically different between freezing protectant products.

## 62 ORAL SESSION 13 (Abstr. 513–519) Vegetable Crops: Postharvest Physiology & Food Science Monday, 24 July, 4:00–5:45 p.m.

## 513

### Simulated Shipment of Fresh-market Tomatoes Utilizing Controlled Atmosphere

James W. Rushing\*; Clemson Univ., Coastal Research and Education Center, Charleston, SC 29414

Mature-green fresh-market tomatoes (*Lycopersicon esculentum* Mill.) were held at 11 °C under controlled atmosphere (CA) at 4% O<sub>2</sub> and 4% CO<sub>2</sub> in a commercial intermodal shipping container equipped with a membrane-based nitrogen-generating CA system. After 4 weeks, tomatoes in CA had 11.9% decay compared to 46.4% decay in control samples held at the same temperature under normal atmosphere. During storage, color development in controls progressed from green to the light red stage in more than 50% of the fruit and only 4.5% remained green after 4 weeks. In contrast, CA stored samples had 25.7% of the fruit in green condition and only 3.9% had progressed to the light red stage. Following CA exposure tomatoes were held at 20 °C with or without 250 ppm C<sub>2</sub>H<sub>4</sub> treatment to observe ripening. All samples ripened normally without symptoms of chilling injury. Results suggest that CA is a useful method for reducing decay and delaying ripening during international transport.

## 514

### Influence of Storage and Sanitizing Protocols on the Physiology of Fresh-cut Watermelon

Jorge M. Fonseca\*<sup>1</sup>, James W. Rushing<sup>2</sup>, and Robert F. Testin<sup>3</sup>; <sup>1</sup>Clemson Univ., Horticulture Dept, Clemson, SC 29634; <sup>2</sup>Clemson Univ., Coastal Research and Education Center, Charleston, SC 29414; <sup>3</sup>Clemson Univ., Packaging Sci. Dept., Clemson, SC 29634

Fresh-cut watermelon cubes stored at selected temperatures within the range of 1.1 to 14.5 °C had decreasing quality shelf life corresponding with increasing temperature. At lower temperatures there was a random occurrence of chilling injury symptoms in some cubes that was associated with the section of watermelon from which the cubes were cut. Cubes removed from the top side of the intact watermelon fruit were more susceptible to chilling injury than cubes from other sectors of the fruit. Sanitizing cubes with chlorine (40 ul/l) or ozone (0.04 µL/L) solutions caused an initial reduction in microbial count, but, during storage, the effect diminished and became insignificant compared to controls. Overall quality was lower in cubes receiving aqueous sanitizing treatments, possibly due to mechanical injury occurring during centrifugation to remove excess solution. Overall quality of cubes exposed to UV light (≈250 nm for 1 to 5 min) was better than cubes receiving aqueous sanitizing treatment. The effectiveness of UV treatment in reducing microbial load was dependent on the amount of cube surface exposed to the light. The results emphasize the importance of preventing microbial contamination during processing of fresh-cut watermelon.

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### Chlorophyll Fluorescence as an Indicator of Anaerobic Metabolite Levels for Broccoli in MAP and Subsequent Air Storage

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When the gas concentrations of modified atmosphere packaging (MAP) become extreme for broccoli (<2 kPa O<sub>2</sub> and >10 kPa CO<sub>2</sub>), off-odors and off-flavors may develop via anaerobic respiration, rendering it unmarketable. We recently showed that chlorophyll fluorescence decreases when broccoli switches to anaerobic behavior in MAP. The objectives of this study were to determine: 1) if chlorophyll fluorescence returns to normal levels after the package is opened and hence the broccoli is exposed to ambient air, and 2) if chlorophyll fluorescence is related to off-odors that develop. Broccoli heads were held in MAP (2 to 3 kPa O<sub>2</sub>

and >10 kPa CO<sub>2</sub>) at 0 to 1 °C for 4, 7, 14, 21, or 28 days, and then 5 days in ambient air at 0 to 1 °C. Chlorophyll fluorescence of the broccoli decreased dramatically in MAP, and remained low during the subsequent 5 days in ambient air. Similarly, off-odors became worse and acetaldehyde, ethanol, and ethyl acetate increased in the broccoli with time in MAP. However, these compounds slightly decreased during the subsequent 5 days of storage in ambient air. Chlorophyll fluorescence parameters correlated negatively with off-odor development and acetaldehyde, ethanol, and ethyl acetate levels in the tissue.

#### 516 Does Diphenylamine Reduce Chilling Injury in Green Bell Peppers?

Albert C. Purvis\*, Horticulture Department, The University of Georgia, Coastal Plain Experiment Station, Tifton, GA 31793-0748

Diphenylamine has been used to reduce low-temperature-induced storage scald of apples for decades. Its effectiveness in reducing scald has been attributed to its antioxidant properties. Oxidative reactions have also been implicated in chilling injury of other commodities, including green bell peppers (*Capsicum annuum* L.). Diphenylamine was applied as a dip at rates of 500 to 2000 ppm to green bell peppers prior to storing them for 7 days at 1 °C. The development of sheet pitting, the most common visible symptom of chilling injury in bell peppers, was inhibited almost completely by diphenylamine. Diphenylamine, however, only slightly reduced the chilling-induced decrease in chlorophyll fluorescence ratios. Darkening of the vascular tissues of the calyxes and seed darkening, which are also symptoms of chilling injury, were not prevented by diphenylamine. Thus, diphenylamine either did not get into all of the sites of oxidative reactions or some of the manifestations of chilling injury are initiated by processes other than oxidative ones.

#### 517 Heat Treatments and Controlled Atmospheres Maintain Quality and Reduce the Inner Leaf Extension or "Telescoping" of Minimally Processed Green Onions

G. Hong\* and M.I. Cantwell; Mann Lab., Department of Vegetable Crops, University of California, Davis, CA 95616

Minimal processing of green onions (*Allium cepa* x *A. fistulosum*) involves trimming and removing damaged leaves, cutting of roots, and removal of the compressed stem. If the stem tissue is completely removed with the roots, the white inner leaf bases may extend, or "telescope," during storage. Storage at 0 °C greatly retards extension growth, but storage at 5 °C results in unacceptable extension rates. To maintain high quality and to extend the shelf life of intact and minimally processed green onions, the potential benefits of heat treatments and controlled atmosphere storage were evaluated. Atmospheres of 0.1% to 0.2% O<sub>2</sub> or 0.1% to 0.2% O<sub>2</sub> containing 7.5% to 9.0% CO<sub>2</sub> at 5 °C were the CA conditions that best maintained visual appearance and prolonged shelf life to more than 2 weeks in both intact and cut onions. No CA treatment completely controlled "telescoping" at 5 °C. Several heat treatment combinations (52.5 and 55 °C water for 4 and 2 min, respectively) of the white inner leaf bases were effective in controlling "telescoping" of cut green onions stored at 5 °C. The effective heat treatments resulted in higher average respiration rates during 12 days, but did not affect the visual quality or shelf life of the cut green onions. Total soluble sugars decreased in intact or cut green onions, but concentrations were maintained in heat-treated onions. Thiosulfinate concentrations did not vary importantly during 14 days at 5 °C, except for a reduction in heat-treated onions not stored under CA.

#### 518 Heat Shocks Applied Either Before or After Wounding Reduced Browning of Lettuce Leaf Tissue

Julio G. Loaiza-Velarde and Mikal E. Saltveit\*, Department of Vegetable Crops, Mann Laboratory, University of California, Davis, CA 95616-8631

The wounds and injuries incurred during minimal processing of lettuce stimulates phenolic metabolism, which leads to tissue browning. Phenylalanine ammonia-lyase (PAL, EC 4.3.1.5.) is the first committed enzyme in the phenylpropanoid pathway and regulates its overall activity. The maximum activity of wound-induced PAL occurs sooner as the temperature increases from 0 to 25 °C, but the maximums are lower. A heat shock at 50 °C for 90 s protects minimally processed lettuce tissue against browning, helps to retain greenness, and decreases the production of phenolics when applied either after or before wounding. Browning is reduced when the heat shock is applied up to 36 h after

wounding, while the maximum effect occurs around 6 h before cutting. Like the heat-shock treatment, a number of protein synthesis inhibitors (e.g., chloramphenicol, cycloheximide, emetine, and puromycin) reduced wound-induced PAL activity, but they did not prevent browning itself. These inhibitors seemed to cause chemical damage that promoted tissue browning. When cycloheximide was applied in combination with heat-shock treatments browning did not occur. Heat shocks appear to control tissue browning by more than just interfering with protein synthesis.

#### 519 Apoplastic Levels of Pectins and Free Galactose in Ripening and Chill-injured Tomato Fruit

Domingos P. F. Almeida\*<sup>1</sup> and Donald J. Huber\*<sup>2</sup>; <sup>1</sup>Crop Science Dept., Univ. Trás-os-Montes e Alto Douro, Apt. 202, 5001-911 Vila Real, Portugal; <sup>2</sup>Horticultural Sciences Dept., Univ. of Florida, Gainesville, FL 32611

Pectin solubility in ripening tomato fruit is typically studied in vitro, employing isolated cell walls; however, it is unknown whether in vitro studies address the actual changes in the status of pectins in the fruit in situ. In vivo pectin solubilization was examined in a pressure-extracted apoplastic fluid obtained from ripening and chill-injured tomato fruit with down-regulated polygalacturonase (PG) activity and untransformed wild-type. Pectin levels in apoplastic fluid increased 3-fold during ripening and were not affected by PG levels. In contrast, PG strongly affected pectin levels in bulk, enzymically active pericarp fluid. There was a 14-fold increase in bulk pectin levels during ripening of PG-antisense fruit and a 36-fold increase in wild-type fruit. Pectin levels in the apoplastic fluid of fruit stored at 5 °C for 14 days were 40% lower than that of freshly harvested mature-green fruit, but increased significantly upon transfer of fruit to 15 °C. Monomeric galactose in the apoplastic fluid increased from 41 mg·mL<sup>-1</sup> at the mature-green stage to 67 mg·mL<sup>-1</sup> in ripe fruit. Bulk levels of galactose were 3- to 4-fold higher than apoplastic levels. After low-temperature storage galactose levels were 50% and 20% lower than in freshly harvested fruit for the bulk and apoplastic fluids, respectively. These results indicate that in vivo pectin solubilization is restricted and largely independent of PG. Low-temperature storage reduces in vivo pectin solubilization, an effect that is reversed upon transfer of fruit to higher temperature following cold storage.

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### 74 ORAL SESSION 14 (Abstr. 520–527) Cross-commodity/No commodity: Human Issues/Extension/Technology Transfer Tuesday, 25 July, 8:00–10:00 a.m

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#### 520 Northeast Greenhouse IPM Notes—Regional Cooperation and Digital Technology Enhances Information Delivery

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Rutgers Cooperative Extension and Cornell Cooperative Extension initiated a regional newsletter the Northeast Greenhouse IPM Notes. The goal of the newsletter is to improve greenhouse pest management practices through promotion of timely integrated pest management information that applies to the unique problems faced in the Northeastern United States. Interstate cooperation maximizes the professional expertise and resources available through several Land Grant Institutions. Extension educators at Cornell, Rutgers, Penn State Univ., and the Universities of Maryland and Connecticut, actively contribute feature articles, pest updates and other timely information through e-mail: Internet communication facilitates communication. The newsletter is prepared monthly and sent to 282 greenhouse growers, extension professionals and allied industry representatives in New Jersey, New York, Pennsylvania, Connecticut, Massachusetts, and other states. The newsletter is also published on the World Wide Web with color images of crop problems. Publishing of color images is facilitated by digital technology. This edition can be downloaded in color from the Rutgers Cooperative Extension Floriculture site: <http://aesop.rutgers.edu/~floriculture/grower/ipmf.htm>

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### **The Effects of Privatization of British and Scottish Public Extension Programs on Agricultural Information Delivery and Technology Transfer**

*Mike Murray\**; University of California Cooperative Extension, Colusa County, Colusa, CA 95932

The British and Scottish public extension programs are currently "privatized," after a decade-long process aimed at this objective. While the British system is owned by a private corporation, the Scottish one is still operated by a public entity. In both situations, information is not freely dispensed, but sold through a subscription process. For a fee, a basic level of service, including newsletters, production/marketing/farm management bulletins, and a limited amount of telephone time with disciplinary/commodity experts, is provided. For an additional fee, farm visits or problem diagnostic services can be secured. The government is one of the largest customers in both systems, funding major "public good" natural resource projects, rural revitalization projects, and agricultural sector job re-training programs. This has significantly impacted the way that information is obtained and delivered to primary producers. These issues, and their implications, will be discussed in this presentation.

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### **Cost Analysis and Perceived Value of Selected Landscape Features**

*Jill Hardy<sup>1</sup>, Bridget Behe\*<sup>1</sup>, Susan Barton<sup>2</sup>, Thomas Page<sup>3</sup>, R. Thomas Fernandez<sup>1</sup>, Robert Schutzi<sup>1</sup>, and D. Bradley Rowe<sup>1</sup>*; <sup>1</sup>Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824; <sup>2</sup>Dept. of Plant and Soil Science, Univ. of Delaware, Newark, DE 19717; <sup>3</sup>Dept. of Marketing, Michigan State Univ., East Lansing, MI 48824

For most residential home improvements, excluding landscapes, professionals can document return on investment. Our objective was to compare costs of installing landscapes with perceived home value, and determine return on investment. We administered surveys in eight selected U.S. cities in 1999. Self-selected participants from home and garden shows were asked to examine a photograph of a home without landscaping (base home), and were given its value estimated by local realtors. Participants were asked to view 16 additional photographs of the base home with different landscapes. Cost estimates for landscape materials and installation were calculated. Results showed that a sophisticated landscape with large and diverse plant material added up to 13% to the perceived value of a new \$200,000 home. On average, any level of landscaping added value to the home. The increase in perceived value as a percentage of project cost was greatest for simple designs with small evergreen plant material. Complicated designs that included hardscapes and large, diverse plant material returned the least. In general, we found that return on investment for landscaping is comparable to the returns gained on several major home improvements, yet differed with respect to geographic region. We found that colored hardscape, developed from a red brick paver walkway, returned less than color from flowering annuals. Return on investment was greatest for annual plants added for color.

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### **A Survey of Distance Learning Needs and Preferences in the Landscape/Nursery Industry**

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The role of cooperative extension in providing information to amateur and professional horticulturists is being profoundly altered by the availability of vast amounts of horticultural resources on the World Wide Web and other electronic media. Advances in computer-related instructional technologies including the Internet, have coincided with, and to some extent triggered, a burgeoning demand for non-traditional continuing education in practically all fields of knowledge, including landscape horticulture. Although there are numerous Web sites offering a wide range of gardening and related information, there are relatively few opportunities for structured learning in the form of on-line distance learning courses or instructional modules. In Fall 1999, we conducted a survey of the membership of the New York State Nursery/Landscape Association to determine priority-training needs that might be met by computer-mediated distance learning. One-hundred-seven companies, representing horticulture-based businesses throughout New York State, completed the surveys. Results from the survey indicated that 83% of those responding were interested in taking one or more computer-based distance learning course(s), that 67% were willing to provide finan-

cial support for continuing education of their employees, and that 95% have access to a personal computer. We have also collected data indicating subject matter preferences, interest in full-course and short-course offerings, levels of computer and Internet experience, and more. It is apparent from the findings in this study that the cooperative extension has a great opportunity to use the World Wide Web as a component of its role as an information provider. This research will contribute to designing effective approaches for teaching hands-on horticultural skills at a distance, thereby expanding the cooperative extension's ability to reach its intended audiences.

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### **Vegetable Production in Southeast Virginia**

*Robert F. Bevacqua\**; New Mexico State Univ., P.O. Box 30003, MSC 3AE, Las Cruces, NM 88003

A research and extension program for increasing vegetable production in southeastern Virginia was launched by Virginia Cooperative Extension in 1997. The launch was triggered by the construction of a shipping point market in Southampton County. First, a market window study identified target crops and the harvest period when they could be most profitably marketed. Target crops were watermelon, sweet corn, snap beans, muskmelon, bell pepper, and pumpkin. Second, a technology transfer program was formulated that emphasized demonstrations, field days, classes, and workshops. On-farm demonstrations of intensive vegetable production techniques formed the foundations of the extension effort and focused on drip irrigation, plastic mulch on raised beds, water and nutrient monitoring, honey bee pollination, and integrated pest management (IPM). "Growing Vegetables for the Commercial Market" was the title of a short course offered in partnership with the local community college. Sixty-five graduates completed the course in 1999. Workshops were offered on farm labor, marketing, irrigation, and production techniques. On-farm research was conducted in support of the emerging vegetable industry. The focus was on sweet corn IPM, variety trials for watermelon and pumpkin, and soil and plant analysis. Information was made available to growers through a bimonthly newsletter, an annual bulletin entitled *Commercial Production Recommendations*, and VCE postings on the World Wide Web.

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### **A Walk through the Garden: Can a Visit to a Botanic Garden Reduce Stress?**

*Tammy C. Kohlleppel\**, Jennifer C. Bradley, and Steve Jacob; Horticultural Sciences Dept., University of Florida, Gainesville, FL 32611

Stress has been called the epidemic of the 90s and has been found to play an important role in causing many diseases. To help cope with the stresses of life, people often seek out leisure activities and nature. Botanic gardens provide a place for experiencing recreational activities and the natural environment. Researchers at the Univ. of Florida developed a survey to gain insight into the influence of a botanic garden on visitor stress. Three botanic gardens in Florida participated in the survey of garden visitors; these included Bok Tower Gardens, Fairchild Tropical Garden, and Mounts Botanical Garden. More than 300 surveys were administered to and completed by visitors of these gardens in Apr. 1999. The survey consisted of three main sections: 1) visitor perceptions of botanic gardens, 2) visitor personal perceptions, and 3) demographic variables. A stress process model was developed that incorporated botanic gardens as a coping strategy. The relative importance of a visit to a botanic garden and other stress process factors were examined for their importance in stress reduction. Also, botanic gardens were placed in context of the stress process model with the development of a multivariate framework. The stress process model included individual factors, stressors, stress mediators, and stress outcomes. Findings from this study provided insight into the role of botanic gardens as a method to cope with the effects of stress. Results showed that a visit to a botanic garden is important in the context of the stress process model as a coping strategy. Data also showed that visitors receiving the most benefit of stress reduction were persons most needing a coping strategy, those having higher depression index scores.

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### **Hawaiian Islands Horticulture: A Prehistoric Perspective**

*Robert F. Bevacqua\**; New Mexico State Univ., P.O. Box 30003, MSC 3AE, Las Cruces, NM 88003

The introduction of horticulture to the Hawaiian Islands by Polynesian voyagers in AD 300 represents the culmination of eastward voyages of discovery by

navigators whose origins were in southeastern Asia and who dispersed an important assemblage of horticultural crops through the Pacific islands. Archaeological, botanical, and linguistic evidence has been used to establish that these voyagers, using double-hulled sailing canoes, transported 27 horticultural plants with them in their voyage of discovery of the Hawaiian Islands. This assemblage included banana, coconut palm, sweetpotato, yam, breadfruit, and taro. The introduction of these plants had a dramatic and damaging impact on the island ecosystem. Many native species of plants and birds became extinct as the settlers used fire as a tool in clearing land for the planting of the introduced plants. A complex civilization developed based on the production of horticultural crops. The staple of food for this society was taro or kalo. The corm or underground portion was mashed with water and eaten as a paste called poi. Large, irrigated, terrace systems were developed for taro production. The most enduring achievement of the Polynesian navigators who explored and colonized the Hawaiian Islands was the dispersal of an assemblage of horticultural plants that transformed the natural environment of both Hawaii and much of the world's tropical regions.

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### Improvement of Agricultural Research Components in Urban Landscape and Greenery of Kuwait

Mahdi Abdal\* and Majda Sulieman; Aridland Agricultural Dept., Kuwait Institute for Scientific Research, Safat, Kuwait

Agricultural development in Kuwait faces many problems and obstacles, such as limitation of water resources for irrigation, soils conditions, climatic extreme (particularly during the summer periods), and trained labor. With these extreme conditions for agricultural development in Kuwait, there is a strong demand from the public and the government for agricultural activities, particularly in urban landscape and greenery. World travel has enhanced the public's desire for the beautification of the urban areas and has emphasized the importance of the urban landscape. Planning urban landscape and greenery for Kuwait depends on various variables and efficient management of limited resources. Irrigation water is limited in Kuwait, and the quality of water is deteriorating from over-pumping of underground water and increased soil salinity by over irrigation and lack of drainage. Efficient irrigation-water management can be improved in Kuwait with enhanced irrigation research and implementation of the recommendations of this research. Research topics can also include water evaporation, which is high in Kuwait, and the introduction of mulching materials to improve water irrigation efficiency. Most of the soils in Kuwait are sandy with limited organic materials and plant nutrients. Research in soil fertility and plant uptake of nutrients is essential for any agricultural activities. Introducing ornamental plants tolerant to drought, salinity, and heat is a continuous research component of urban landscape and greenery in Kuwait. Training local staff in basic agricultural activities and research development should improve resource management and enhance the greenery of Kuwait.

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## 75 ORAL SESSION 15 (Abstr. 528–535)

### Fruits/Nuts: Crop Physiology

Tuesday, 25 July, 8:00–10:00 a.m

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### Modeling of Fruit Set in Apple—Approaches, Model Structure, and Initial Results

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Several models of apple tree carbon balance have been developed, including a simplified model by our lab. Tree photosynthesis and total dry matter production is the best characterized except for root growth and root respiration. Once dry matter is produced and partitioned to the different organs (another key problem for modeling), the effects of carbon availability to the fruits on their growth and abscission needs to be modeled. Our approach is based on an observed relationship between increased abscission with decreased fruit growth rate of populations of fruit. From several empirical studies of fruit growth and abscission during chemical thinning or imposed stress early in the season, a relationship was found between % abscission and classes of fruit growth rates. It appears to be

best if the fruit growth rate is expressed as a percent of the growth rate of the fastest growing group of fruits in each study. Thus in the model the fruit growth allowed by the available carbon each day is compared to a pre-determined maximum growth rate for the cultivar. The percent-of-maximum growth rate then determines how much abscission will occur. Then the growth rate of the remaining fruit is calculated. Additional parameters of the model allowed for a multiple-day buffer of carbon availability, an imposed fruit number reduction (i.e. equivalent to hand thinning), and temperature effects. Although there are more improvements planned, the initial tests have been promising with the simulations showing realistic patterns of fruit abscission and fruit growth.

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### Pollen Tube Growth in Stage 2 Pollinated Avocado Flowers

Thomas L. Davenport\*; University of Florida, IFAS, Trop. Res. & Ed. Ctr., Homestead, FL 33031

Individual avocado (*Persea americana* Mill.) flowers are perfect, opening two times to display two distinct reproductive stages on consecutive days. Stage 1 focuses on presentation of pistils and Stage 2 on presentation of pollen. The Stage 1 opening offers the greatest opportunity for outcrossing due to the absence of available pollen in that stage. Stage 2 flowers, however, are self-pollinated within flowers in direct proportion to the number of white stigmas present at the time of pollen dispersal. The potential success of these self-pollination events was examined in orchard trees of seven commercial Florida cultivars: Booth 7, Brooks Late, Choquette, Monroe, Simmonds, Tonnage, and Tower 2 and compared with hand-pollinations from complementary cultivars (cross pollination) and from flowers of the same cultivar (close pollination). The furthest advancement of pollen tubes down styles and into the ovaries on their way to the egg apparatus was noted in hundreds of individual flowers 24 and 48 h after pollen deposition on receptive white stigmas of the Stage 2 flowers. Virtually none of the seven cultivars exhibited pollen tubes reaching the egg apparatus by 24 h after deposition. By 48 h, however, pollen tubes had reached the egg apparatus in 25% to 85% of the pollinated flowers, depending upon cultivar. Pollen source was inconsequential. The results demonstrate the success of self-pollination in avocados. It is especially important for cultivars growing in humid climates, which display a high proportion of receptive white stigmas in Stage 2.

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### Graft-transmissible Agents Affect Membrane Fatty Acid Saturation During Chilling Accumulation and Dormancy Release in Peach

Phillip G. Gibson\*<sup>1</sup>, Gregory L. Reighard<sup>1</sup>, Gary L. Powell<sup>2</sup>, and Thomas C. Jenkins<sup>3</sup>; Departments of <sup>1</sup>Horticulture, <sup>2</sup>Biological Sciences, <sup>3</sup>Animal and Veterinary Sciences, Clemson University, Clemson, SC 29634

Graft-transmissible agents found in 'Ta Tao 5' peach have been associated with phenological changes, including delay in bloom, reduced shoot vigor, and early autumn defoliation. Peach Latent Mosaic Viroid (PLMVd) is present as a graft-transmissible agent in 'Ta Tao 5'. In order to further characterize the changes occurring in trees exposed to PLMVd from 'Ta Tao 5' grafts, total fatty acid content was measured for peach buds during chilling accumulation and release from dormancy in 'Coronet' peach trees and 'Coronet' trees treated with 'Ta Tao 5' bud grafts. Palmitic (16:0), stearic (18:0), oleic (18:1), linoleic (18:2), and linolenic (18:3) acids were the major fatty acids in dormant and releasing peach buds of both the controls and treated trees. The degree of unsaturation increased immediately following completion of chilling requirement in both the untreated controls and in the treated trees. However, the desaturation of linoleic acid to linolenic acid was significantly inhibited in the trees treated with 'Ta Tao 5' bud grafts, which was accompanied by a concomitant delay in the resumption of growth. The disparity between the control and treated trees in the trend toward increased fatty acid unsaturation continued through the resumption of growth. The changes in degree of fatty acid saturation correlated with a response to forcing conditions and the release from dormancy. The presence of PLMVd in 'Coronet' peach trees affects membrane fatty acid saturation during chilling accumulation and dormancy release. These findings suggest that metabolic pathways involving fatty acid desaturation are linked to the phenotypic variation in trees exposed to PLMVd.

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**CMN-Pyrazole-induced Abscission of Mature 'Valencia' Oranges in Relation to Young Fruit, Root, and Shoot Growth**  
*Rongcai Yuan\**, *Ulrich Hartmond*, and *Walter J. Kender*, University of Florida, Institute of Food and Agricultural Sciences, Citrus Research and Education Center, 700 Experiment Station Road, Lake Alfred, FL 33850

The seasonal abscission response of mature 'Valencia' oranges [*Citrus sinensis* (L.) Osb.] to 5-chloro-3-methyl-4-nitro-1H-pyrazole (CMN-Pyrazole) was examined in relation to young fruit, shoot, and root growth. CMN-Pyrazole dramatically increased ethylene production in fruit and effectively reduced the fruit detachment force (FDF), except in a period of reduced response to CMN-Pyrazole in early May. Root growth was inhibited by trunk girdling, in combination with removal of spring vegetative flushes and flowers, but not by their removal alone. During the responsive period, there was no difference in both ethylene production and FDF of CMN-Pyrazole-treated mature oranges between 1) the unmanipulated trees and those manipulated by either 2) girdling, removal of spring flushes and flowers, or 3) removal of flushes and flowers alone. However, during the less-responsive period, ethylene production in CMN-Pyrazole-treated mature oranges was significantly lower while the FDF was higher from non-manipulated trees than from trees treated by either girdling and removal of flush, or only removal of flush. There was no difference in either ethylene production or FDF of CMN-Pyrazole-treated mature oranges between trees manipulated by girdling and removal of flush, and those by removal of flush alone. Flush growth terminated at least 2 weeks before the onset of the less responsive period. This suggests that the hormones from rapidly growing young fruit may be responsible for the less responsive period.

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**Endogenous Gibberellins in Developing Apple Seeds in Relation to Biennial Bearing**

*Yicheng Tu\**<sup>1</sup>, *Peter Hirst*<sup>1</sup>, *Ronald Coolbaugh*<sup>2</sup>, and *Richard Pharis*<sup>3</sup>; <sup>1</sup>Department of Horticulture, <sup>2</sup>Department of Horticulture, <sup>2</sup>Department of Botany and Plant Pathology, Purdue University, West Lafayette, IN 47907 USA; <sup>3</sup>Department of Biological Sciences, University of Calgary, Canada

It is believed that gibberellins (GA) produced in apple seeds act as an inhibitory signal to flower induction in the neighboring buds. The alternate bearing behavior of an apple cultivar is therefore likely to be associated with the activity of endogenous GAs in the seeds of that cultivar. To elucidate the impact of GAs on the flowering of biennial and non-biennial apple cultivars, fruits were sampled from 'Fuji' (biennial, on-year) and 'Gala' (non-biennial) trees periodically during the early part of the growing season. Seeds were removed from fruits immediately, frozen in liquid nitrogen and freeze dried. Full scan analysis for GAs using GC-MS identified 16 GAs: GA<sub>1</sub>, GA<sub>3</sub>, GA<sub>4</sub>, GA<sub>7</sub>, GA<sub>20</sub>, GA<sub>31</sub>, GA<sub>34</sub>, GA<sub>35</sub>, GA<sub>44</sub>, GA<sub>50</sub>, GA<sub>54</sub>, GA<sub>61</sub>, GA<sub>63</sub>, GA<sub>68</sub>, GA<sub>80</sub>, and GA<sub>88</sub>. In addition, we also traced a number of GA-like mass spectra that do not match any published GA mass spectrum reference. The possible structures of these GA-like compounds were also proposed. More types of GAs were found in 'Fuji' seeds than in those of 'Gala'. This suggests higher GA activity in 'Fuji' considering almost all the GAs identified are biologically active. Unlike the results of recent researches on GAs in other apple cultivars, we found that the major GA types in both cultivars are GA<sub>80</sub> and GA<sub>63</sub>, rather than GA<sub>4</sub> and GA<sub>7</sub>. 'Fuji' contained significant amounts of GA<sub>88</sub>, which did not appear in 'Gala' samples. Other studies are currently underway to quantify specific GAs from these seeds using deuterated internal standards.

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**Monitoring Soil Water Content in Tropical Fruit Orchards in Southern Florida with Multi-sensor Capacitance Probes and Tensiometers**

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Tropical fruit trees in southern Florida are grown in porous, oolitic limestone soil that has very low organic matter content and water-holding capacity. Thus, trees require frequent irrigation during dry periods. In these soils, a quantitative basis for monitoring soil water content to determine when and how much to irrigate has been lacking. Multi-sensor capacitance probes (EnviroSCAN™, Sentek, Australia) were installed in commercial carambola, lime, and avocado orchards to continuously monitor changes in soil water content at depths of 10, 20, 30, and 50 cm. Eight probes were installed per orchard. Volumetric soil water content was recorded at 15-min intervals with a solar-powered datalogger. Results were

downloaded to a laptop computer twice a week. Monitoring the rate of soil water depletion (evapotranspiration) allowed irrigation before the onset of water stress. The time at which soil reached field capacity could be determined after each irrigation (or rain) event. Soil water tension was recorded periodically using low-tension (0–40 cbars) tensiometers placed adjacent to selected capacitance probes at 10- and 30-cm depths. Soil water tension was better correlated with volumetric soil water content at a 10-cm depth than at 30-cm depth. Using multi-sensor capacitance probes is a highly accurate, although relatively expensive, method of monitoring soil water content for scheduling irrigation in tropical fruit orchards. Whereas tensiometers require periodic maintenance, the multi-sensor capacitance probe system has been virtually maintenance free. The correlation between soil water content and soil water tension obtained in situ indicates that tensiometers are a less precise, but considerably cheaper, alternative for scheduling irrigation in tropical fruit orchards in southern Florida.

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**Use of Infrared Thermal Imagery for Ground-based and Real-time Detection of Water Deficit in Fruit Trees**

*Rita Giuliani\** and *James A. Flore*, Dept. of Horticulture, Michigan State Univ. East Lansing, MI 48824-1325 USA

Ground-based infrared thermal imagery was applied for early detection of plant water deficit, i.e., before photosynthetic activity is depressed and before growth processes are negatively affected by water shortage. Remote and real-time sensing of radiative canopy surface temperature was performed in Michigan in Summer 1999 on peach and apple orchards, using a digital IR imaging radiometer. Still images and videos were acquired on single canopies of well-watered plants and plants subjected to water depletion. Atmospheric parameters were monitored simultaneously. On apple trees, the apparent canopy temperature showed a wider thermal dispersion [10 °C], compared to peach tree canopies [2–5 °C]. Central tendency and shape parameters describing the canopy thermal distribution could identify, even for apple canopies, the thermal signal [1–2 °C] of plant water deficit, before changes in leaf net photosynthetic rate and fruit diameter were observed. The results of this study support the application of digital infrared thermal imagery and image processing for early recognition of plant water deficit. The decrease of the cost of available thermographic cameras makes their use feasible.

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**Oxygen Radical Absorbance Capacity (ORAC), Phenolic, and Anthocyanin Concentrations in Fruit and Leaf Tissue of Highbush Blueberry**

*Mark Ehlenfeldt\**<sup>1</sup> and *Ronald L. Prior*<sup>2</sup>; <sup>1</sup>Blueberry and Cranberry Research Center, 125A Lake Oswego Road, Chatsworth, NJ 08019; <sup>2</sup>USDA/ARS, Jean Mayer Human Nutrition Research Center on Aging at Tufts Univ., Boston, MA 02111

Antioxidant capacity as measured by ORAC, total phenolic, and total anthocyanin concentrations were evaluated in leaf tissue of the same 86 highbush blueberry cultivars, and ORAC and phenolic levels evaluated in leaf tissue of the same materials. Average values for ORAC, phenolics, and anthocyanins in fruit were 15.9 ORAC units (1 unit = 1 μmol Trolox Equivalent), 1.79 mg/g (gallic acid equivalents), and 0.95 mg/g (cyanidin-3-glucoside equivalents), respectively. 'Rubel' had the highest ORAC values, at 31.1 units. Values for ORAC and phenolics in leaf tissue were significantly higher than fruit tissue, with mean values of 490.4 ORAC units and 44.8 mg/g in leaf tissue, respectively. No significant correlations were found between fruit ORAC and leaf ORAC, or between fruit ORAC and leaf phenolics. Investigation of ORAC values in a family of 44 'Rubel' x 'Duke' seedlings showed negative epistasis for ORAC values. However, an analysis of ORAC values vs. pedigree in plants from the 86 cultivar groups suggested that, across cultivars, ORAC inheritance is generally additive.

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**84 ORAL SESSION 16 (Abstr. 536–543)**  
**Vegetable Crops: Nutrition**  
**Tuesday, 25 July, 10:00 a.m.–12:00 noon**

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**The Gradient—A Nutritional Paradigm Shift**

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A gradient concept was initiated and evaluated at the Gulf Coast Research and Education Center, Bradenton, during the 1960s as the nutritional component in a full-bed mulch system of production. Commercial tomato yields in Florida more than doubled with the shift to the gradient-mulch system. Conventionally, nutrients move to the root in the water by mass flow and thus are a function of water requirement. With the soil as the buffer component, nutrient input may or may not be synchronized with root removal. Movement with the gradient is by diffusion and the nutrient/water input is synchronized with rate of removal by the root. The limited buffer potential of the soil is replaced by the gradient with an unlimited buffer potential. Production in the field or a container has a maximum potential with the gradient procedure but can become limited in the field and a failure in the container with conventional procedure. The gradient requires minimal soil (a framework for the gradient) uses minimal water, creates minimal pollution, requires minimal management and provides a nutritional stability that has an unlimited productivity potential. The N-K banded on the soil bed surface in conjunction with a continuing water supply are the basic parameters of the gradient concept.

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**Impacts of Farming Systems and Soil Characteristics on Processing Tomato Fruit Quality**

Giuseppe Colla<sup>1</sup>, Jeff Mitchell<sup>1</sup>, and Durga Poudel<sup>2</sup>; Department of Vegetable Crops, University of California, Davis CA 95616; <sup>2</sup>Department of Agronomy and Range Science, University of California, Davis, CA 95616

A 2-year field study was conducted within the Sustainable Agriculture Farming Systems Project at the Univ. of California, Davis, to evaluate the effects of long-term conventional (CONV), low-input (LOW), and organic (ORG) production practices on processing tomato fruit mineral composition and quality. To establish relationships between soil chemical properties, soil water content, fruit mineral composition, and quality, this study characterized soil chemical properties and monitored soil water content through each tomato season. Soil total C, N, soluble P, exchangeable Ca, K, and Na were higher in the organic system than in the conventional system. Higher soil electrical conductivity was found in the CONV system compared to the other systems. Low input plots had soil characteristics intermediate to the other farming systems. Marketable and unmarketable yields were similar among the farming systems. Fruit N and Na were lower in the organic and low-input systems than in the conventional system. Fruit P and Ca contents were higher in the organic system than in the conventional system as a result of 11 years of manure applications. Soluble solids content, titratable acidity, color, and soluble solids yield were lower in 1998 in the organic system than in the conventional system, while no differences were found in 1999. Soil water content during the ripening stage was the major factor affecting the soluble solids content of the organic system. In the low input and conventional systems soluble solids content was most related to soil exchangeable Ca and EC, respectively.

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**Understanding Why Horticultural Crops in the Desert Rarely Respond to K Fertilization**

Charles A. Sanchez\*, Abraham Galadima, and Jeffrey C. Silvertooth; University of Arizona, Yuma Ag. Center, 6425 W. 8th St., Yuma, AZ 85364

Vegetable and fruit crops produced in the desert southwestern United States generally do not respond to K fertilization. Even when pre-plant soil test K levels are low and crop K accumulations are high, responses are infrequent. We have performed a number of evaluations aimed at understanding why crops produced in this region fail to respond to K fertilization. First, data show the potential for substantial K inputs through irrigation. For example, Colorado River water, which is widely used for irrigation in this region, contains ≈5 ppm K, resulting in potential K inputs of 30 to 60 kg K/ha. Second, many of the soils used for crop production have a clay content and mineralogy making a response to K unlikely. Studies

evaluating the kinetics of K release from the mineral fraction of soils in the region has shown that many soils used for crop production have a high capacity to replenish K to the soil solution and exchange sites following crop uptake. Finally, the observation that Na can partially substitute for the K requirement of many fast-growing leafy vegetables may also be a contributing factor for the infrequent K fertilizer responses for these commodities.

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**Assessing Soil and Water Thresholds for Potential Dietary Zinc Toxicity in Selected Vegetable Crops**

X.E. Yang<sup>1</sup>, X.X. Long<sup>1</sup>, W.Z. Ni<sup>1</sup>, and E.W. Stover<sup>2</sup>; <sup>1</sup>Dept. Soil Sci. & Plant Nutr., Zhejiang Univ., Hangzhou 310029, China; <sup>2</sup>Indian River Res. & Ed. Center, Univ. of Florida, Ft. Pierce, FL 34945

Vegetables play an important role in the human diet, and production in sub-urban areas has increased as populations have become more urbanized. However, heavy metal pollution of soils has enhanced in such areas, and metal accumulation in vegetables may pose a human health risk when consumed. Zinc is an essential micronutrient for plants and humans, but it is toxic to plants and humans at high levels. Although a maximum Zn tolerance for human health has been established for edible parts of vegetables (20 mg/kg DW), little information is available for predicting vegetable Zn concentration based on soil and water Zn levels. The objectives of this study were to determine the critical Zn concentrations in nutrition solution and soil to reach maximum Zn tolerance concentrations in Chinese cabbage, bok choy, and celery. Five Zn levels were used for both solution and soil culture experiments, with three replicates of each. Shoot growth was significantly inhibited at Zn concentrations above 50 mg/L in nutrition solution and above 180 mg/kg in soil. The sensitivity of crops to zinc toxicity, in term of shoot and root growth, decreased in the order: celery > Chinese cabbage > bok choy. Zinc accumulation in shoots and edible parts varied with Zn supply levels and type of vegetables. A negative correlation was noted between Zn accumulation and dry matter yields, with r-squared values of 0.980\*\* for nutrient solution and 0.960\* for soil culture. Zinc concentrations in shoots or edible vegetable parts were below 20 mg/kg (human health threshold) when they were grown at DTPA extractable Zn in the soil less than 75, 100, and 175 mg/kg for bok choy, celery, and Chinese cabbage, respectively.

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**Influence of Calcium Nutrition on Growth and Tissue Electrolyte Leakage in Carrot (*Daucus carota*)**

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The influence of calcium (Ca<sup>++</sup>) nutrition on the growth and root tissue electrolyte leakage (EL) of carrot (*Daucus carota*) was investigated using a hydroponic culture system. Seedlings of 'Navajo' carrot were grown for 10 weeks with roots submerged in hydroponic nutrient solutions containing 0, 0.1, 1, 2, 4, or 8 meq/L Ca<sup>++</sup>. The nutrient solution was replenished weekly with its pH maintained at 5.8 for the entire experimental period. The tap root lengths increased as solution Ca<sup>++</sup> concentration increased. The diameter and fresh and dry weights of the tap roots increased as Ca<sup>++</sup> concentration increased up to 4 meq/L, and then decreased at 8 meq/L Ca<sup>++</sup>. The root and petiole concentrations of sugar, potassium, and nitrate were unaffected by changes in nutrient solution Ca<sup>++</sup> levels. The tissue EL, when tested for the stored roots, decreased as solution Ca<sup>++</sup> concentration increased ( $r = 0.602$ ). Results of this experiment suggest that calcium nutrition is essential for maintaining cell wall integrity in hydroponically grown carrot roots.

541

**Effect of Supplemental Calcium on Watermelon Yield, Fruit Weight, Soluble Solids, and Calcium Content of Leaves and Fruit**

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Inadequate available Ca can cause blossom end rot in watermelons. Many products and materials are marketed to try and help reduce this problem. A 3 X 3 factorial was set up with three soil Ca treatments (none, 1120 kg/ha of dolomite and 1120 kg/ha of gypsum) and three foliar Ca treatments (none, Liqui-Cal at 9.35 L/ha and Foli-Cal at 4.67 L/ha) using both a seeded (2N) and seedless (3N) cultivar. Mehlich-1Ca level prior to planting was 305 ppm. None of the Ca treatments affected leaf or fruit Ca levels. Applied Ca treatments did not affect total



yields, fruit weight, or percent soluble solids of the seedless cultivar (Crimson Trio). Yield of 'Royal Flush' (2N) was reduced by application of Foli-Cal, but none of the other parameters were affected by the other Ca treatments. Leaf Ca level of 'Royal Flush' (3.05%) was almost twice that of 'Crimson Trio' (1.59%), while fruit Ca content of 'Royal Flush' (0.26%) was lower than that of 'Crimson Trio' (0.32%).

542

#### Sulfur Source, Rate, and Method of Application for Polyethylene-mulched Tomato

Anas D. Susila\* and Sal J. Locascio; Horticultural Sciences Department, University of Florida, Gainesville, FL 32611

Tomato (*Lycopersicon esculentum* L.) was grown with polyethylene mulch and drip irrigation on a Millhopper fine sandy soil testing very high in P and low in organic matter during two seasons to evaluate the effect of S source, rate, and application methods on plant growth and yield of fruit. S rates of 34 and 68 kg S/ha were applied preplant (broadcast in the bed), by drip (10 weekly drip applications), and by split applications (40% preplant and 60% drip). In split applications, S sources evaluated were ammonium sulfate and ammonium thiosulfate. Plant height was increased with S application from 0 to 68 kg S/ha in both studies. However, response on plant dry weight only occurred in Spring 1999. Total marketable yield was 17.9 tons/ha with 0 kg S/ha and was increased quadratically to 48.1 tons/ha with application of 68 kg S/ha in Spring 1999, but no response to S was obtained in the Spring 1998 study. Measured variables were not affected by S source and methods of application. Increasing S application from 0 to 68 kg S/ha reduced leaf and plant tissue P concentration 14% and 12% at mid season and 26% and 25% at late-season sampling, respectively. Application of 68 kg S/ha reduced soil pH  $\approx$ 0.3 unit at the end of the season in both studies.

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#### Effect of Calcium and Sulfur on Yield of Late-storage Cabbage

Alan McKeown\* and Cathy Bakker; Department of Plant Agriculture, University of Guelph, Simcoe, ON N3Y 4N5, Canada

Soil and crop management practices suggest the possibility of sulfur deficiency for cole crops in Southern Ontario. A 3-year study was conducted to evaluate rates of calcium and sulfur on yield of 'Huron' late-storage cabbage. Treatments were based on  $\text{CaSO}_4$  applied at 0, 1000, 2000, and 3000  $\text{kg}\cdot\text{ha}^{-1}$  'Novacal' (Ca 27%, S 19%, Mg 2.5%, Dolomex Inc., Portage-du-Fort, Quebec, Canada), a granulated gypsum product. Potassium sulfate and calcium nitrate were used as elemental controls. Potassium and nitrogen levels were balanced with potassium chloride and ammonium nitrate. Phosphorous applications were based on soil analysis. All treatments were applied pre-plant incorporated. This trial was repeated on sand and loam soils typical of soil used for cabbage production in southern Ontario. Applications of sulfur increased yield of cabbage on sand and clay, although the optimum rate varied from year to year. Medium and high rates produced the highest yield in the first year, while low rates were more effective in the second and third seasons. Response of cabbage to calcium varied from year to year. Medium and high rates of calcium increased yield on sand, but had no effect on clay in the first year. Calcium had no effect on yield on either soil type in the second year. However, in the third year, low rates of calcium produced the highest yield on both sand and clay. Although there were no visual symptoms of deficiency, applications of sulfur, and to a lesser extent calcium, increased yield indicating that a 'hidden hunger' for these elements may exist on some soils in southern Ontario.

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## 85 ORAL SESSION 17 (Abstr. 544–549) Woody Ornamentals/Landscape/Turf: Crop Production/Propagation Tuesday, 25 July, 10:00–11:15 a.m.

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544

#### Using Chlorophyll Fluorescence in Storage and Vegetative Propagation of *Taxus*

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Propagation failures of *Taxus* are often attributed to cutting collection from stock plants of poor quality. If a quick, reliable method of determining the potential rooting of cuttings based on the condition of a specific stock plant was available for propagators, rooting success could be predicted before investing time, labor, and resources. Our studies examined chlorophyll fluorescence ( $F_v/F_m$ ) as a potential tool for stock plant selection, assessment of storage conditions, and measurement of stress over the course of propagation. Ten cultivars of *Taxus x media* (*Taxus baccata* L. x *T. cuspidata* Sieb. & Zucc.) were used: Brownii, Dark Green Pyramidalis, Dark Green Spreader, Densiformis, Densiformis Gem, Hicksii, L.C. Bobbink, Runyan, Tauntoni, and Wardii. Storage condition treatments consisted of desiccation (low, medium, and high), duration (34, 70, and 107 days), and temperature ( $-30$ ,  $-2.5$ ,  $0$ ,  $2.5$ ,  $5$ ,  $10$ , and  $20$  °C). Cultivars differed in  $F_v/F_m$  initially as well as over time. Correlations were not found between initial stock plant  $F_v/F_m$  and rooting percentage, number of roots, root dry weight, or root length, indicating that  $F_v/F_m$  is not a reliable indicator of stock plant propagation potential. Short storage duration at  $-2.5$  to  $2.5$  °C was found to be ideal.  $F_v/F_m$  could detect substandard storage conditions only at temperature and desiccation extremes. Although chlorophyll fluorescence measurements do not appear to be a practical method of predicting adventitious rooting, there is a potential for assessing cutting or plant quality before shipping.

545

WITHDRAWN

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#### Seed Germination of *Abelia x grandiflora* (Andre) Rehd.

S.M. Scheiber\*<sup>1</sup>, Carol D. Robacker<sup>1</sup>, and M.A. Dirr<sup>2</sup>; <sup>1</sup>Dept. of Horticulture, Georgia Station, Univ. of Georgia, Griffin, GA 30223; <sup>2</sup>Dept. of Horticulture, Univ. of Georgia, Athens, GA 30602

Flowering evergreen shrubs that are compact and resistant to pests are in great demand in the nursery and landscape industries. The genus *Abelia* contains 30 species that vary in many traits including flower color, growth habit, and hardiness. *Abelia x grandiflora* (Andre) Rehd. and its cultivars are the most widely grown *Abelia* taxa and are characterized by pest resistance, an abundance of pinkish white flowers, long flowering period, and glossy evergreen foliage. Interspecific hybridization among *Abelia x grandiflora*, its cultivars, and other species in the genus *Abelia* offer the potential for new cultivars; however, seed germination within the genus has been described as slow and inconsistent. Experiments were conducted to test procedures to increase germination percentages and rates. Each *Abelia* seed is enclosed in a leathery achene. The effect of achene removal was examined in combination with cold, moist stratification for 60 days at 4 °C, immersion in 100 ppm gibberellic acid for 24 h, and no treatment. Treatments were replicated five times with 15 seeds per replication. Seeds were sown on sphagnum peat, and grown under mist in the greenhouse. Weekly germination counts were recorded for 8 weeks. Seeds with attached achenes germinated at a significantly higher percentage than those without achenes. Cold, moist stratification and gibberellic acid treatments were not significantly different than the control. No significant differences were found within the achene treatments for relative rate of emergence, but significant differences were found for the time until 90% of final emergence was reached.

### Nursery Crops for Nutrient Recovery in Treatment Wetlands

Thomas Holt\*, Brian Maynard, and William Johnson, University of Rhode Island, Department of Plant Sciences, Kingston, RI 02881

Constructed wetlands are an effective, low-cost method of water treatment that may reduce agricultural pollutants from nursery runoff. It has been suggested that the expense of implementing such systems could be recovered by growing aquatic plants that could be sold to retail and wholesale markets. However, this demand could probably be satisfied through a few wetlands. It would be desirable if more traditional nursery crops could be incorporated into treatment wetlands. Several taxa of *Canna*, *Iris*, and ornamental grasses are selected cultivars of wetland plants that have been used in treatment wetlands for decades. However little data exists on these cultivar's nutrient uptake rates and survivability in treatment wetlands. Nutrient uptake and growth rates of *Canna x generalis* cultivars 'Aflame', 'King Humbert', and 'Pretoria', *Glyceria maxima* 'Variegata', *Iris pseudacorus*, *Iris versicolor*, *Phalaris arundinacea* 'Luteo-Picta', *Pragmites australis* 'Variegata', and *Spartina pectinata* 'Aureo-marginata' were compared to the widely used *Typha latifolia*. Single divisions of each were established in a constructed wetland and batch fed weekly a commercial fertilizer solution reconstituted to 100 ppm-N. Plants were harvested after 75 days and biomass and tissue nutrient content was determined. Mean biomass of *Typha latifolia* was 212 g/division and nitrogen and phosphorus accumulation was 4.5 and 0.8 g/division, respectively. The biomass of the other species ranged from 101 to 175 g/division and had total accumulation of nutrients ranging from 2.5 to 3.8 g nitrogen/division and 0.35 to 0.85 g phosphorus/division.

### 548

#### Antitranspirant Treatments Affect Stock Plant Growth and Rooting Percentage in Two Members of the Oleaceae Family

Susan Switras\* and Jeffrey Gillman, University of Minnesota, Department of Horticultural Science, 305 Alderman Hall, St. Paul, MN 55108

*Syringa vulgaris* L. 'Montaigne' (French hybrid lilac) and *Chionanthus virginicus* L. (white fringetree) stock plants were sprayed with two film-forming antitranspirants, Clear Spray and sodium silicate, and one stomate-regulating antitranspirant, atrazine. After 30 days of growth, cuttings were taken from both species. Shoot calipers of antitranspirant-treated lilacs increased at a slower rate than the control lilacs. There were no long-term shoot length changes in lilac due to antitranspirant treatments. Shoots of Clear Spray-treated fringetrees increased in length significantly less than other treatments. Rooting was evaluated once a week from week 3 until 6 weeks after cuttings were taken for lilac and every 2 weeks from week 6 to 12 weeks after sticking for fringetree. All treatments resulted in 80% to 85% rooting in lilac after 6 weeks, but Clear Spray-treated plants rooted more quickly. Fringetree cuttings treated with Clear Spray had a significantly lower rooting percentage (15%) than the other treatments (35% to 50%).

### 549

#### Three New Cultivars of Flowering Dogwood Resistant to Powdery Mildew

R.N. Trigiano\*, M.T. Windham, and W.T. Witte, Tennessee Agriculture Experiment Station, Dept. of Ornamental Horticulture and Landscape Design, The Univ. of Tennessee, Knoxville, TN 37901-1071

Powdery mildew (*Microsphaera pulchra*) of flowering dogwood (*Cornus florida* L.) has become a significant problem of trees in nursery production as well as in the landscapes and forests of the eastern United States. The disease significantly reduces growth and berry production by older established trees and may contribute to the inability of younger trees (liners) in production to survive winter dormancy. Disease resistance in named cultivars is limited to partial resistance found in 'Cherokee Brave'—all other cultivars are extremely susceptible. Until now, the only disease control measure was to establish an expensive, labor-intensive, preventive fungicide program. We examined >22,000 seedlings and identified 20 that were extremely resistant to powdery mildew. Three trees with white bracts were selected from the 20 and released as patent-pending cultivars. 'Karen's Appalachian Blush' has long, non-overlapping, pink fringed bracts with a delicate appearance. 'Kay's Appalachian Mist' has creamy white, slightly overlapping bracts with deeply pigmented clefts. 'Jean's Appalachian Snow' has large, strongly overlapping bracts with non-pigmented clefts. The three powdery mildew-resistant cultivars will be entered into an existing breeding program with 'Appalachian Spring', a cultivar released by the Tennessee Agriculture Experiment Station and

resistant to dogwood anthracnose, in an attempt to produce trees that are resistant to both diseases.

## 98 ORAL SESSION 18 (Abstr. 550–557)

### Vegetable Crops: Genetics/Breeding/ Biotechnology

Tuesday, 25 July, 2:00–4:00 p.m.

### 550

#### Mapping of QTL for Partial Physiological Resistance and Field Reaction to White Mold, Plant Architecture, and Plant Height in Common Bean

Soon O. Park\*<sup>1</sup>, Dermot P. Coyne<sup>1</sup>, James R. Steadman<sup>1</sup>, Paul W. Skroch<sup>2</sup>, and Geunhwa Jung<sup>2</sup>; <sup>1</sup>Univ. of Nebraska, Lincoln, NE 68583; <sup>2</sup>Univ. of Wisconsin, Madison, WI 53706

The objective was to detect molecular markers associated with QTL for partial physiological resistance (PPR) to two white mold (WM) isolates, partial field resistance (PFR), plant architecture (PA), and plant height (PH) in a genetic linkage map constructed using recombinant inbred lines (RILs) from the cross 'PC-50' (resistant to WM) x XAN-159 (susceptible to WM). Significant correlations (+0.39 and +0.47) were noted between the WM reactions in the greenhouse and field. A significant but negative correlation (−0.33) was observed between the WM reaction and PH in the field. Six QTL affecting PPR to isolate 152 were found on LGs 4, 5, 7, and 8. Six QTL affecting PPR to isolate 279 were found on LGs 2, 3, 4, 7, and 8. Five QTL for PFR were observed on LGs 2, 5, 7, 8, and 11. Two QTL affecting PA were detected on LGs 7 and 8. Two QTL affecting PH were identified on LGs 7 and 8. On one end of LG 8 marker H19.1250 was significant for PPR to both isolates. On the other end of LG 8 the region closely linked to the *C* locus was significantly associated with PPR to both isolates, PFR, PA and PH. Marker J09.950 on LG 7 was significantly associated with PPR to both isolates, PFR, PH and seed weight. Marker J01.2000 on LG 2 was the most significant locus for both PPR to the isolate 279 and PFR. QTL on LG 5 were found for PPR to the isolate 152 and PFR. Overall, four of the five QTL affecting PFR were also found for PPR to one or both isolates.

### 551

#### Inheritance of Tomato Late Blight Resistance Derived from *Lycopersicon hirsutum* LA1033 and Identification of Molecular Markers

Rebecca C. Lough\* and R.G. Gardner, Dept. of Horticultural Science, North Carolina State Univ., Raleigh, NC 27695

During the last century *Phytophthora infestans* (Mont.) de Bary, which causes the devastating disease late blight of tomato and potato, has been controlled with pesticides. Recently, the difficulty of controlling late blight has increased due to the appearance of new strains of *P. infestans* that are more virulent and are resistant to metalaxyl. Numerous *P. infestans* resistance genes exist within the Solanaceae; however, most of these are race-specific and have the potential of being overcome. To achieve durable resistance, it may be necessary to utilize multi-genic resistance or gene pyramiding. The *Lycopersicon hirsutum* Kunth accession LA1033 is highly resistant to *P. infestans*. To incorporate resistance into a useful background, the *L. esculentum* Miller inbred line NC215E was used as a recurrent parent in backcrossing with *L. hirsutum* LA1033. A population of 264 BC<sub>3</sub>F<sub>1</sub> plants derived from 11 BC<sub>2</sub>F<sub>2</sub> families was planted at Fletcher and Waynesville, N.C., in July 1998 in a replicated field trial. BC<sub>3</sub>F<sub>2</sub> seed were collected from a single highly resistant BC<sub>3</sub>F<sub>1</sub> plant. The BC<sub>3</sub>F<sub>2</sub> population was tested for resistance using a detached leaf screen. To verify growth chamber test results, BC<sub>3</sub>F<sub>3</sub> seeds were collected from the BC<sub>3</sub>F<sub>2</sub> individuals and were planted in a field trial at Fletcher in July 1999. The ratio of resistant to susceptible progeny fit the expected ratio for an incompletely dominant trait controlled by two loci. To identify molecular markers linked to the resistance loci, DNA was extracted from the highly resistant and susceptible BC<sub>3</sub>F<sub>2</sub> individuals, and bulks of DNA were constructed. The resistant and susceptible bulks were screened with AFLP (amplified fragment length polymorphism) markers. Results of the AFLP study indicate marker linkage to resistance.

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### Comparison of Genetic Diversity in between Two Germplasm Banks Containing *Lycopersicon esculentum* Accessions

James Nienhuis<sup>1</sup>, Julie Rodríguez<sup>1</sup>, Wilber Phillips<sup>2</sup>, Peter Hanson<sup>2</sup>, and Liliway Engle<sup>3</sup>; <sup>1</sup>Dept. of Horticulture, University of Wisconsin, Madison, WI 53706; <sup>2</sup>Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica; <sup>3</sup>Asian Vegetable Research and Development Center (AVRDC), Sanhua, Taiwan, R.O.C.

Worldwide, there are currently more than 60 germplasm banks that contain tomato (*Lycopersicon esculentum*) collections ranging in size from a few dozen to several thousands of accessions. In the utilization of these genetic resources sampling from only one germplasm bank may result in limiting available genetic diversity, whereas sampling from several germplasm banks may result in unnecessary redundancy. The current lack of knowledge regarding the relative magnitudes of genetic diversity contained within different collections makes it difficult to develop a core collection that maximizes genetic diversity. Two large tomato collections are housed at the Asian Vegetable Research and Development Center (AVRDC), Sanhua, Taiwan, R.O.C., and the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica. Ninety-six accessions from CATIE and 102 accessions from AVRDC were randomly sampled from each base collection. The total of 198 accessions were characterized for 103 polymorphic RAPD molecular marker bands. The results indicated that the two germplasm banks sampled different genetic diversity. In addition, the magnitude of genetic diversity was greater in the AVRDC collection compared to CATIE.

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### Genetic Diversity in Papua New Guinea Sweetpotato Germplasm

Diego Fajardo<sup>1</sup>, Don R. La Bonte<sup>1</sup>, and Robert L. Jarre<sup>2</sup>; <sup>1</sup>Dept. of Horticulture, Louisiana State University, Baton Rouge, LA 70803-2120; <sup>2</sup>USDA/ARS, Plant Genetic Resources, 1109 Experiment Street, Griffin, GA 30223

The USDA gene bank currently maintains 668 accessions of cultivated sweetpotato and 219 accessions of related *Ipomoea* species. Information on the genetic diversity of the collection does not exist due to funding constraints. The development of a core collection would provide a subset of accessions that represent the genetic diversity of the main collection with a minimum of repetitiveness. The small size of the core collection would facilitate the evaluation of the accessions for economically important traits. The objective of this research is to develop a core collection of Papua New Guinea sweetpotato germplasm using the Amplified Fragment Length Polymorphisms (AFLPs) marker system. This approach to quantifying genetic diversity would later serve as a model for the development of a USDA sweetpotato germplasm core collection. The germplasm chosen for this study was collected from this crop's secondary center of genetic diversity based on its potential as a source of new traits. All genotypes were fingerprinted using four primer combinations that generated 224 markers. The molecular data was then analyzed using NTSYSpc 2.0 program to determine the relatedness of the genotypes. The molecular analysis showed a homogeneous genetic constitution. The extent of diversity among accessions was correlated with the geographic origin of the plant material.

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### Mapping of QTL for Seed Size and Shape Traits in Common Bean

Soon O. Park<sup>1</sup>, Dermot P. Coyne<sup>1</sup>, Geunhwa Jung<sup>2</sup>, Paul W. Skroch<sup>2</sup>, E. Arnaud-Santana<sup>3</sup>, and James R. Steadman<sup>1</sup>; <sup>1</sup>Univ. of Nebraska, Lincoln, NE 68583; <sup>2</sup>Univ. of Wisconsin, Madison, WI 53706; <sup>3</sup>CIAS, Apartado #145, San Juan de la Maguana, Dominican Republic

Our objective was to identify QTL for seed weight (SW), length, and height segregating in a recombinant inbred line (RIL) population from the cross 'PC-50' (Larger SW) x XAN-159 (Smaller SW). The parents and RILs were grown in two separate greenhouse experiments in Nebraska, and in field plots in the Dominican Republic and Wisconsin. Data analysis was done for individual environments separately and on the mean over all environments. A simple linear regression analysis of all data indicated that most QTL appeared to be detected in the mean environment. Composite interval mapping (CIM) analysis was then applied to the means over environments. Eight QTL for SW were detected on common bean linkage groups (LGs) 3, 4, 5, 6, 7, and 8. All eight markers associated with these QTL were significant in a multiple regression analysis (MRA), where the full model explained 63% of the variation among SW means. Six QTL for seed length were

detected on LGs 2, 3, 4, 8, and 11 using CIM. The markers associated with the three seed length QTL on LGs 2, 8, and 11 were significant in a MRA with the full model explaining 48% of the variation among seed length means. Three QTL for seed height on LGs 4, 6, and 11 explained 36% of the phenotypic variation for trait means. Four of the six QTL for seed length and two of three QTL for seed height also appeared to correspond to QTL for SW.

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### Estimation of Genetic Diversity among Citrullus Accessions using RAPD Markers

Amnon Levi<sup>1</sup>, Claude E. Thomas<sup>1</sup>, Anthony P. Keinath<sup>2</sup>, and Todd C. Wehner<sup>3</sup>; <sup>1</sup>USDA, ARS, U.S. Vegetable Laboratory, 2875 Savannah Hwy., Charleston, SC 29414; <sup>2</sup>Clemson Univ. Coastal Research and Education Center, 2865 Savannah Hwy., Charleston, SC 29414; <sup>3</sup>Dept. of Horticultural Science, North Carolina State Univ., Raleigh, NC 27695-7609

Genetic relatedness was estimated among 42 U.S. plant introduction (PI) accessions of the genus *Citrullus* (37 PIs of which were reported to have disease resistance and five watermelon cultivars) using 30 RAPD primers. These primers produced 662 RAPD markers that could be scored with high confidence. Based on these markers, genetic similarity coefficients were calculated, and a dendrogram was constructed using the unweighted pair-group method with arithmetic average (UPGMA). The analysis delineated three major clusters. The first cluster consisted of a group of five watermelon cultivars, a group of *C. lanatus* var. *lanatus* accessions and a group of *C. lanatus* var. *lanatus* accessions that contained some *C. lanatus* var. *citroides* genes. The second cluster consisted of the *C. lanatus* var. *citroides* accessions, while the third cluster consisted of the *C. colocynthis* accessions. The two *C. lanatus* clusters differentiated from each other and from the *C. colocynthis* cluster at the level of 58.8% and 38.9% genetic similarity. Our results indicate that closely related *Citrullus* PIs may have resistances to the same diseases. Thus, molecular markers may be a useful tool in the development of core collections of *Citrullus* PIs with resistance to diseases.

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### In Vitro Anther Culture of Cucumber (*Cucumis sativus* L.)

M.H. Aboul-Nasr<sup>\*</sup> and M.A. Ahmed; Dept. of Horticulture, Assiut Univ., Assiut, Egypt

This experiment was performed at the Tissue Culture Laboratory of the Horticulture Dept. of the Faculty of Agriculture at Assiut Univ., Egypt. After several attempts to determine the proper stage of buds for collection of pollen, we determined that the tetrad stage was most suitable. The pollen was cultured on either MS or B5 liquid or solid media (7% agar). Both media were used as basic salts or supplemented with growth regulators. The four growth substances were BA, NAA, K, and 2,4-D. Each growth substance was added to the medium separately as follows: BA, NAA at 15, 10, or 5 ppm; K at 0.1, 1, 2, or 5 ppm; and 2,4-D at 0.5, 1, or 5 ppm. The solidified medium was superior to the liquid medium at all the treatments that were used for callus formation. Using B5 medium did not result in any callus. The highest value of callus formation was obtained when MS medium supplemented with BA at 5 ppm. Moreover, the callus that was grown on the MS medium that had BA at 5 or 10 ppm developed a meristem tip. The control treatment produced calluses but did not develop any meristem tips. This process can be used to develop haploid plants.

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### Germplasm Evaluation of Thirty-nine and Ecological Adaptation Trials of Seven Tomato (*Lycopersicon esculentum*) Varieties in Nigeria

Olufolaji, O.A. Denton, Margaret J. Makinde<sup>\*</sup>, and J.A. Akinfasoye; National Horticultural Research Institute (NIHORT), Idi-Ishin, P.M.B. 5432 Ibadan, Nigeria

Nigeria has diverse ecological conditions, ranging from mangrove swamp of the southern coastal regions to the derived Savannah of the middle belt and the Sudan/Guinea Savannah of the Northern part of the country. Using the southern wet humid rainforest condition of NIHORT, Ibadan, two germplasm evaluation trials were carried out during the rainy season of May to Sept. 1996 and 1997. Thirty-nine tomato accessions were investigated on 1 x 4-m plots at 50 x 75-cm spacing in a completely randomized block design with three replications. The top 10 and the least 10 accessions were evaluated for yield in terms of number and weight of both wholesome and unwholesome fruits. In the Northern Guinea Savannah, NHL-10; Ti 423, and Ti 420 were the best three in terms of fruit number (141 to 117) and weight (673–583 g) per m<sup>2</sup>. In the northern Sudan Savannah,

Ti. 420; NHLY, Ai7 topped the list with (125–72 fruits) and 500–420 g per m<sup>2</sup>. In the southern rainforest of Ibadan, NHLY, 10; Ti 420, and Ti 423 were superior in fruit number (33–12) and weight (327–150 g/m<sup>2</sup> to all the other accessions. However, in the derived Savannah of Ikirun, Ti 423; Roma VF, AND Ti 420 with (85–56 fruits) and (589–278 g) per m<sup>2</sup> were quite outstanding among the seven accessions.

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## 99 ORAL SESSION 19 (Abstr. 558–564) Floriculture/Foliage: Nutrition/Media Tuesday, 25 July, 2:00–3:45 p.m

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### Nutrient Allocation Patterns of *Lupinus hvardii* Wats under Different Preharvest Ca Fertilization Regimes

Mario Valenzuela-Vazquez\* and Geno A. Piccioni; Dept. of Agronomy and Horticulture, New Mexico State Univ. Box 30003, Las Cruces, NM 88003-0003

*Lupinus hvardii* (Big Bend bluebonnet) is a winter annual plant indigenous to the semiarid southwestern U.S. with potential to become a new cut flower commodity. Nothing is presently known about the mineral nutrition of bluebonnet in greenhouse conditions, either in the whole plant or its short-lived cut racemes, and its possible relationship with vase life longevity. At first appearance of floral buds, supplemental Ca treatments (0, 2.5, 5.0, and 10.0 mM Ca using CaCl<sub>2</sub>) were added to the nutrient solution over a 2-month growing period, to evaluate the influence of Ca on plant nutrient allocation patterns, nutrient uptake and utilization, and raceme physiology after cutting. Ca supplementation increased net Ca uptake per plant by 40%, 77%, and 95% over the control (2.5, 5.0, and 10.0 mM Ca, respectively;  $P < 0.05$ ). The increased Ca uptake per plant increased Ca concentration in racemes (a weak Ca sink), which resulted in marginal increases in vase life duration (1 day). This positive influence on vase life duration was not significant due to limited number of raceme replicates. When plants were supplemented with 5 mM Ca, the net accumulation of Ca, P, K, and Mg in roots increased by 4 to 5 times over the control roots. These increases occurred in parallel to an increase in root dry matter production. Similar patterns were observed in the net accumulation of Ca, P, K, and Mg per plant. In our conditions, Ca supplementation (5 mM) enriched raceme Ca concentration as well as whole-plant consumption of Ca, P, K, and Mg in bluebonnet plants. These data will be useful in developing fertilization strategies for this new and promising greenhouse floral crop.

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### Preferential Allocation and Inducible Calcium Sinks in Leaf Primordia of *Dracaena sanderiana* Hort. Sander ex M.T. Mast (Dracaenaceae)

Svoboda V. Pennis\*, Dennis B. McConnell, and Michael E. Kane; Dept. of Environmental Horticulture, Univ. of Florida, Gainesville, FL 32611

We induced preferential allocation of Ca to two calcium oxalate (CO) sinks in immature leaf tissues of *D. sanderiana*: subepidermal extracellular deposits and intracellular raphides. Allocation was affected by exogenous Ca levels. Two groups of rooted cuttings were termed Ca-deficient and non-deficient. The first group consisted of cuttings that had been deprived of Ca for 18 months, and, the second, cuttings rooted under standard horticultural conditions. All plants were grown in liquid medium supplemented with 100 ppm of potassium nitrate and subjected to 0, 3, or 7 mM Ca from calcium acetate. The most striking feature of Ca-deficient plants grown in 0 mM Ca was the absence of intracellular raphides in the leaf primordia. The largest number of intracellular raphides developed in Ca-deficient plants grown in 7 mM Ca. The number of extracellular crystals in Ca-deficient plants grown in Ca-supplemented solutions versus non-supplemented were similar, but crystals were considerably smaller in non-supplemented plants. Total number of extracellular crystals per epidermal cell did not differ significantly between plants in all treatments. This implies that nucleation sites are pre-determined and finite in number. In contrast, the number of intracellular raphides was highly variable. In terms of Ca prioritization, the extracellular crystals took precedence over intracellular raphides, and this was most obvious in Ca-deficient plants. The significance of this research is that the extracellular crystals represent Ca sinks with limited induction capacity compared to intracellular Ca sinks. Plants with genetic predisposition for intracellular CO crystal formation may be able to

respond favorably to root environments with low Ca levels compared to species with limited capacity for intracellular CO deposition. Intracellular CO crystals, therefore, play an integral role in plant nutrition as Ca storage sinks.

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### Rose Plant Tolerance to NaCl Salinity

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Yield, quality, and nutrient status of 'Bridal Pink' (on *R. manetti* rootstock) roses were evaluated under increasing NaCl salinity and mixed NO<sub>3</sub><sup>-</sup>/NH<sub>4</sub><sup>+</sup> nutrition. Container-grown plants were irrigated over eight flushes of growth and flowering with nutrient solutions having 100 NO<sub>3</sub><sup>-</sup>: 0 NH<sub>4</sub><sup>+</sup>, 75 NO<sub>3</sub><sup>-</sup>: 25 NH<sub>4</sub><sup>+</sup>, and 50 NO<sub>3</sub><sup>-</sup>: 50 NH<sub>4</sub><sup>+</sup> ratios in combination with three NaCl concentrations. During the first four flowering flushes, NaCl was supplemented at 0, 5, and 10 mM, but these concentrations were increased to 0, 15, and 30 mM during the last four flushes. Interestingly, NO<sub>3</sub><sup>-</sup>: NH<sub>4</sub><sup>+</sup> ratios and NaCl concentration had no main effects over any flower yield or quality component evaluated over the 13-month experimental period. Furthermore, visual symptoms of apparent salt injury were just observed during the last three flowering cycles, and mostly on the oldest foliage of plants receiving the highest salt concentrations (30 mM). Leaf N and Na concentrations were not significantly affected by the treatments over the course of the experiment, averaging 3.34% and 45 mg·kg<sup>-1</sup>, respectively. Leaf Cl concentrations were significantly increased by salt additions, ranging from 1000 to 15,000 mg·kg<sup>-1</sup> [0.1% to 1.5% dry weight (DW)]. Correlation analyses revealed that relative dry weight yields increased with leaf Cl concentrations up to 3000 mg·kg<sup>-1</sup> (0.3% DW) but were significantly depressed at higher concentrations. These results confirm recent reports suggesting that roses are more tolerant to salinity than their typical classification of sensitive. Furthermore, this is the first known study to report an apparent positive effect of moderate leaf Cl concentrations on rose biomass yields.

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### Reduction of Fertilizer Inputs Using Earthworm Castings as a Substrate Amendment for Poinsettia Production

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Earthworm castings were evaluated to determine the effect of earthworm castings on growth of Poinsettia 'Freedom Bright Red'. Castings derived from cow (CC), horse (HC), or sheep (SC) manure were combined with peatmoss at 1:0, 1:3, 1:1, 3:1, or 0:1 peat : castings (v/v). One plant was potted per 1.5-L container and were fertilized at 0, 50, 200, or 350 mg/L N in a RCB arrangement. Plant growth index at all fertilizer rates was greatest when grown in SC at 0:1, 1:3, and 1:1 and CC at 0:1 and 1:3 (peat : castings) ratios. For each of the three animal sources, no differences in growth index were observed among fertilizer rates when 100% castings was used as the substrate. Bract area was greatest on plants grown in SC at 1:0, 1:3, and 1:1 (peat : castings) ratios at all four fertilizer rates. Bract area on plants grown in CC at 0:1 and 1:3 (peat : castings) was less than SC, but better than CC at 1:1, 3:1, or 1:0 or any of the HC substrates. Plants grown in substrates with 75% or more castings all had similar bract area regardless of fertilizer rate. As castings in the substrate decreased, bract area increased as fertilizer rate increased. When fertilized at 0, 50, or 200 mg/liter N plant dry weight decreased as castings increased in the substrate. Fertilization at 350 mg/liter did not affect dry weight between substrates.

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### Incorporating Zeolite into Soilless Container Media Reduces Nutrient Leaching in Ornamental Plant Production

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Containerized ornamental plant production represents extremely intensive agricultural production. An average of 200,000 containers may occupy 1 acre of surface area, to which a large amount of chemical fertilizers will be applied. Because of the use of high-drainage soilless potting mixes coupled with excessive fertigation, a great amount of nutrients, particularly nitrogen and phosphorus, are leached, which increases the potential for ground and surface water contamination. Over the past 2 decades, research has been centered on developing fertigation delivery systems such as nutrient film techniques, ebb-and-flow and capillary mat systems, for reducing leaching. Relatively limited research has been con-

ducted on improving potting medium substrates to minimize nutrient leaching. The objectives of this study were to determine the adsorption isotherm of six different zeolites to ammonium, nitrate and phosphorus, identify and incorporate desired zeolites in a peat/bark-based medium for reducing nutrient leaching in ornamental plant production. Results indicated that the zeolites possess great holding capacities for ammonium, nitrate, and phosphorus. Compared to control, ammonium leaching was reduced 70% to 90%, phosphorus 30% to 80% and nitrate 0% to 60% depending on zeolite species and quantity used per pot. Zeolite amended media caused no adverse effects on plant growth. Conversely, biomass increased significantly when compared to that of the control.

563

### Development of the Press Extraction Method for Plug Substrate Analysis: Quantitative Relationships Between Solution Extraction Techniques

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Methods for extracting growing substrate root-zone solution include the saturated media extract (SME) and the 2 water : 1 substrate (v/v) suspension, neither of which are particularly suited to bedding plant plug systems. We have developed the press extraction method (PEM) as a simple and quick alternative to these methods. The grower simply collects a representative sample of plug trays and presses the top of the plug, collecting the expelled solution. Solution pH and EC can be measured immediately and the sample then sent to an analytical laboratory for nutrient analysis. Initial experiments demonstrated that differing manual pressures did not affect solution chemical properties. The PEM then was compared to the SME and 2:1 methods over a range of fertilizer levels and with peat- and coir-based substrates. Within substrates, pH, EC, and macronutrients were similar between the PEM and the SME. The level of dilution inherent in the 2:1 method resulted in much lower EC and nutrient levels when compared to the other two methods. Further experiments compared the PEM to the SME and 2:1 on plug flats collected from several commercial greenhouses and also those grown in the research greenhouse. The wide range of bedding plant species and fertility levels tested introduced variation needed to develop regression equations and correlations to create quantitative interpretation ranges for the PEM based on previously published sufficiency ranges for the SME and 2:1.

564

### Screening Commercial Peat and Peat-based Products for the Presence of Ericoid Mycorrhizae

Mark Starrett<sup>\*</sup>, College of Agriculture and Life Science, Dept. of Plant and Soil Science, The Univ. of Vermont, Burlington, VT 05405-0082

A study was conducted to investigate the presence of ericoid mycorrhizal fungi in select peat and peat-based products. *Vaccinium corymbosum*, a known host of ericoid fungi, was used as a model plant. Peat and peat-based products were obtained from all major sources that supply the northeastern United States. Seedling roots were examined and average percent colonization was determined for each sample. Results indicate that these fungi are present in the majority of peat and peat-based media tested. Seedlings grown in some of the selected media exhibited an increased percentage of colonized root cells. Mycorrhizal fungi colonizing roots of test plants were isolated. These fungi exhibited typical ericoid fungal growth characteristics.

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## 100 ORAL SESSION 20 (Abstr. 565–571) Cross-commodity: Undergraduate Education/Master Gardeners Tuesday, 25 July, 2:00–4:00 p.m

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### Use of Cooperative Learning Exercises to Introduce Concepts in Potted Plant Production Classes

Neil O. Anderson<sup>\*</sup>; Dept. of Horticultural Science, University of Minnesota, 1970 Folwell Ave., St. Paul, MN 55108

In production classes, students often commence the class by learning complicated crop-specific production cycles. Rarely are they afforded the opportunity of spending several class periods to first understand the major differences between commercial crops for production time, labor input, and market share. A cooperative learning exercise was created for the first week of lectures in potted plant production class (Hort 4051) at the Univ. of Minnesota (n = 18 students). Students were assigned to working groups for discussion and synthesis of the assignment. One week later, each group turned in their recommendations and one lecture session was devoted to in-class discussion of their answers. The exercise was in the form of a memo from a commercial company, Floratech, addressed to the students as the newly hired potted plant production specialists. In the memo, a graphical summary was presented of 13 major and minor potted crops, contrasting total production time, labor input, and market share for each crop. As production specialists, the student's primary task was to interact with all staff (other students role-playing various positions within the company) to answer the following question: "What is the most realistic, cost-effective location on the graph that Floratech should aim to move all crops?" Group discussions, both within and outside of class, focused on the noticeable trends depicted by the graph and the limiting factors that prevented crops from moving to the ideal location. Growers and breeders were quizzed on what factors kept each crop in the specific locations on the graph. The majority of student chose the midpoint of the graph as the best location. The exercise successfully peaked student's awareness of crop differences and the limiting production factors. Throughout the semester, students referred back to this graph to pinpoint the location for each crop covered.

566

### Barriers Encountered in Establishing Effective Distance Education Programs

D.L. Auld<sup>\*1</sup>, M.J. Cepica<sup>2</sup>, and C.B. McKenney<sup>1,3</sup>; <sup>1</sup>Dept. of Plant & Soil Science, Texas Tech Univ.; <sup>2</sup>College of Agr. Sci. & Natural Resources, Texas Tech Univ., Lubbock, TX 79409; <sup>3</sup>Texas A&M Univ. Res. & Ext. Center, Dallas, TX 75252

Distance education is an area of rapid expansion in higher education today. Unfortunately, the development of distance education efforts, like all new programming, is fraught with numerous barriers. Frequently, technological advances precede internal policies necessary to support these activities, and because of the nature of distance education, concerns over expense, workload, intellectual property, conflict of interest and teaching methodology may impede progress. Funding distance education efforts also requires long-term vision and commitment. It is essential that a clear vision, including identification of existing needs and benefits, be developed before equipment and personnel are secured. Finally, some distance education efforts by their nature involve collaboration between other institutions of higher education. These schools may view participation in these programs as opportunities for their advancement or possible encroachment on their educational market. Establishing strong relationships is essential for ultimate success. At Texas Tech Univ., the College of Agricultural Sciences and Natural Resources along with the Dept. of Plant and Soil Science have committed to the development and implementation of distance education as an educational tool providing enrichment and access to high-quality programming for its on campus and place-bound students. Some of the success stories as well as the frustrations behind these efforts will be discussed.

567

### Teaching Techniques and Course Modifications used to Enhance Horticulture Courses Utilizing Interactive Video Conferencing

C.B. McKenney<sup>\*1,4</sup>, D.L. Auld<sup>1</sup>, M.J. Cepica<sup>2</sup>, and J.B. Storey<sup>3</sup>; <sup>1</sup>Dept. of Plant & Soil Science, Texas Tech Univ.; <sup>2</sup>College of Ag. Sci. & Natural Resources, Texas Tech Univ., Lubbock, TX 79409; <sup>3</sup>Dept. of Hort. Sci., Texas A&M Univ.; <sup>4</sup>College Station, Texas; <sup>4</sup>Texas A&M Univ. Res. and Ext. Center, Dallas, Texas

Interactive video conferencing provides a useful medium for distance education. Due to the highly visual nature of many horticulture courses, the multimedia techniques utilized in video conferencing provide a rich platform from which to conduct many aspects of these efforts. Video conferencing also requires an overall evaluation of which common teaching techniques work and what possible

modifications may be necessary to accomplish the desired teaching goals. Some of the topics for consideration in utilizing interactive video conferencing include encouraging participation of remote students, overcoming the feeling of viewing television, identifying the desired level of involvement by the students with the technology, considering alternative methods to reach desired course objectives, coordinating evaluation and testing, implementing classroom management techniques, and adding high touch to the high tech medium. Texas Tech and Texas A&M Universities have utilized interactive video conferencing at both the undergraduate and graduate levels. Some of the successful techniques as well as identification of a few of the pitfalls will be discussed.

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### **Challenges and Opportunities in Academic Advisement for Non-traditional Horticulture Students**

*George E. Fitzpatrick\** and *Kimberly A. Klock-Moore*; University of Florida, Fort Lauderdale Research and Education Center, 2305 College Ave., Fort Lauderdale, FL 33314

The average undergraduate horticulture major at the Univ. of Florida Academic Program at Fort Lauderdale is 38 years old. The older, non-traditional student population is quite diverse, but many individuals are motivated by a desire to change careers, and many of them have taken extensive academic course work at other institutions prior to applying for admission to the Univ. of Florida. Academic advisement of this type of student presents a substantial challenge because of the uncertainty of content and vigor of prior academic preparation. To help meet this challenge, we have developed several academic advisement checklists that indicate numbers and titles of critical preprofessional and general education courses from the academic institutions that have been most frequently attended by the highest numbers of the incoming non-traditional students. These checklists have been cross-referenced between the catalogs of the various academic institutions and the Univ. of Florida catalog. We use these documents to evaluate the academic preparation of incoming transfer students and to assist them in making correct course selections to remedy any academic deficiencies that could negatively influence their success in upper division horticulture course work.

569

### **HCC 100: Horticultural Science—A Course Redesigned to Meet the Biological/Physical Sciences Requirement of the All University Core Curriculum**

*Harrison Hughes\**; Dept. of Horticulture and Landscape Architecture, Colorado State University, Fort Collins, CO 80523

Colorado State Univ. recently underwent the development of a new all university core curriculum. All faculty were encouraged to submit proposals for new courses or revised courses, which would be reviewed for inclusion under specified categories. Basic Horticulture was redesigned to emphasize the scientific method, the understanding between science and society, and the use of hands-on and inquiry-based instruction in the laboratory. Horticultural Science is now an applied science course that includes the use of hypothesis formulation, experimentation, observation, data collection, summation and presentation in scientific format of reports of at least three laboratory exercises, as well as extensive general observation and presentation in both written and oral format. It teaches science in the context of everyday interaction with the environment in which the student lives, the interior and exterior plants that surrounds the student at CSU, and the controversies as well as the health aspects that surround the production of foods derived from plants that require intensive cultivation. Examples of such issues include sustainability, the organic movement, genetically modified organisms, ground water pollution from overfertilization, and water usage for landscaping and golf courses in a water short region. A review of the revisions as noted above and the use of technology in teaching the course will be presented.

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### **Development, Implementation, and Evaluation of a Non-majors Survey Course**

*Jennifer Campbell Bradley\**, *Dennis McConnell*, and *Tammy Kohlleppe*; Department of Environmental Horticulture, University of Florida, Gainesville, FL 32611

Attracting new students into traditional agriculture programs has become increasingly difficult. The idea of offering a course as a means for introducing students to agriculture is a concept with popular appeal. As a recruiting effort, and as a method of introducing students to horticulture, the Environmental Horticulture Dept. at the Univ. of Florida designed a one-credit course for non-majors. The course was struc-

ured such that a broad understanding of horticulture, including production, landscaping, and floriculture, would be emphasized. The intent was to develop a course somewhat similar to an entry-level course, but incorporating a more enjoyable, practical, hands-on approach. ORH 1030 Plants, Gardens, and You was offered for the first time in summer 1997. It is now offered every semester. The course has one faculty assigned each semester and various other faculty members, including teaching, research, and extension specialists who participate as "guest lecturers". Student response to ORH 1030 has been favorable, ratings are high and enrollment in the course has continued to rise from 30 to our current cap of 100. As a means of ensuring that we are meeting the needs of our students and to aid in targeting potential students, a survey was administered in Spring 2000. Students enrolled in the course were surveyed at the beginning and the end of the semester to gain insight into student demographics, horticulture background and experience, reasons for enrollment in the class, attitude toward horticulture and overall interest in horticulture. Findings will be discussed in addition to information and suggestions for successfully establishing a similar course in other horticulture departments.

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### **Undergraduate and Graduate Curriculum in Public Horticulture at The University of Tennessee**

*Susan L. Hamilton\*<sup>1</sup>* and *Mary L. Albrecht<sup>2</sup>*; <sup>1</sup>Dept. of Ornamental Horticulture & Landscape Design, <sup>2</sup>College of Agricultural Sciences & Natural Resources, University of Tennessee, Knoxville, TN 37901

Students wanting to prepare for a career in public horticulture can now enroll in a new undergraduate and graduate curriculum at the Univ. of Tennessee. Beginning fall semester, 1999, students enrolled in the Dept. of Ornamental Horticulture and Landscape Design (OHL) can opt to follow the new Public Horticulture concentration in the ornamental horticulture and landscape design major. The Public Horticulture concentration was the result of a year-long curriculum revision that reflects growth in career options in horticulture. The goal of the Public Horticulture concentration is to prepare students for careers that promote horticulture and emphasize people and their education and enjoyment of plants. Such careers include director of a botanical garden, arboretum, or park; city or urban horticulturist; extension agent, teacher, educational director, or program coordinator; professional garden writer/editor or publication manager; horticulture therapist; public garden curator; and plant collections manager. The Public Horticulture concentration allows students to take a breadth of ornamental horticulture courses, five of which are specific to public horticulture, along with supporting course work in soils, entomology, plant pathology, and botany, while providing the opportunity for students to take electives in education, extension, public administration, grant writing, museology, psychology, information sciences, journalism, and management. Students also complete an internship for graduation and have the opportunity to work in the Univ. of Tennessee Inst. of Agriculture Gardens.

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### **Basic Botany On-Line: A Training Tool for the Oregon State Univ. Master Gardener Program**

*Ann Marie VanDerZanden\*<sup>1</sup>*, *Bob Ros<sup>2</sup>*, and *Rick Ecker<sup>2</sup>*; <sup>1</sup>Dept. of Horticulture, <sup>2</sup>Extension and Experiment Station Communications, Oregon State Univ., Corvallis, OR 97331-7304

At Oregon State Univ. (OSU), a team of educators and web designers developed a noncredit, on-line training module for the OSU Master Gardener program. The on-line module consists of the botany component of the annual Master Gardener training. It is comprised of text from the botany chapter in the Master Gardener handbook, an on-line discussion group, on-line quizzes for each section, a clickable glossary, links to additional educational resources on the web, a few animations, and numerous photographs and line drawings. To evaluate the effectiveness of this learning tool a group of 24 Master Gardeners (all graduates of the Master Gardener training program from previous years) tested the module via their home computers. Additionally usability testing was completed with a group of eight Master Gardener volunteers. These participants navigated through the course in a computer lab setting while they were observed by the development team. Participants from both groups completed an evaluation regarding technical issues, organization and presentation of the module, navigation throughout the module, and content as well as user satisfaction. Overall participants felt this was a useful training tool for the Master Gardener program and that it would be a useful addition to the annual training. They also noted that features such as the on-line discussion group and accessibility of e-mail made them feel connected

to the other on-line learners as well as to the course instructor. This module will be used as the primary training tool for the botany component of the annual training for over 75 new trainees in 2000.

## 101 ORAL SESSION 21 (Abstr. 573–580)

### Fruits/Nuts: Crop Production

Tuesday, 25 July, 2:00–4:00 p.m

573

#### Enhancing Red Color Development Without Over-ripening Apples by AVG (Aminoethoxyvinylglycine) Followed by Ethephon Treatment

Zhenyong Wang\* and David R. Dilley, Dept. of Horticulture, Plant and Soil Sciences Bldg., Michigan State Univ., East Lansing, MI 48824

AVG applied alone to 'Gala' and 'Jonagold' apples delayed maturity and the onset of the ethylene climacteric and delayed red color development. AVG followed by ethephon delayed maturity and the onset of the ethylene climacteric, but promoted red color development of both cultivars. Ethephon applied alone advanced maturity, ethylene production, ripening, and red color development compared to AVG alone. In other studies, the ripening-related effects of these treatments were reflected in the storability of fruit in CA storage. AVG - and AVG + ethephon-treated fruit were still at preclimacteric ethylene levels after 6 months in CA storage, with excellent retention of flesh firmness and shelf-life, while ethephon and control fruits had significantly higher ethylene levels and softened more during storage and shelf-life evaluation. Collectively, our results indicate that an ethephon application following AVG treatment may be useful to overcome the delay of red color development of apples treated with AVG only and that this can be achieved without overly stimulating fruit ripening. Thus, a once-over harvest of 'Gala' and 'Jonagold' apples may be achieved with a significant reduction in harvest costs. We attribute the promotion of red color development of apples receiving AVG treatment with a follow-up application of ethephon to the action of ethylene temporarily-released from ethephon stimulating the development of the anthocyanin biosynthetic pathway, while AVG inhibits the development of the endogenous ethylene climacteric. Inhibiting endogenous ethylene production delays fruit from producing their own ethylene. We attribute maturation uniformity to the action of AVG allowing the less mature fruits to gain maturity while slowing maturity development of the more mature fruits. Improved storability of AVG + ethephon-treated fruit is attributed to the same ethylene-related phenomena.

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#### Nitrogen, Trunk Scoring, and AVG Treatments Influence Fruit Color and Quality of 'Jonagold' Apple

James M. Wargo\*, Ian Merwin, and Christopher Watkins, Dept. of Fruit and Vegetable Science, Cornell University, Ithaca, NY 14853

'Jonagold' apple often has problems of inadequate red blush development at harvest, and loss of firmness and skin "greasiness" after refrigerated storage. During two growing seasons we tested factorial combinations of three preharvest treatments for managing these problems: 1) N fertilization (no applied N, 34 kg N/ha in May, or 1% (w/w) foliar urea sprays in May and June); 2) mid-summer trunk scoring (girdling); and 3) aminoethoxyvinylglycine (AVG) applications 3 weeks prior to harvest. Fruit were harvested at four weekly intervals each year, and evaluated for size, blush, firmness, soluble solids, ethylene, and starch hydrolysis. Nitrogen delayed blush development in 1998, but not 1999, and there was no difference in fruit surface blush coverage between foliar urea and soil applied N. Nitrogen applications increased fruit size, decreased fruit firmness, and increased post-storage flesh breakdown in 1999. Trunk scoring increased blush coverage and intensity both years, and improved market-grade packouts. Blush increase after trunk scoring was not caused by advanced fruit maturity (based on ethylene and starch indices) in either year, although it did increase skin greasiness slightly. AVG treatments delayed maturity and blush development of 'Jonagold' by 7 to 10 days both years, relative to untreated fruit. Flesh firmness increased and greasiness decreased in AVG treated fruit harvested on the same dates as controls. However, in AVG fruit harvested at comparable stages of maturity 7 to 10 days later, firmness and greasiness were equivalent to untreated

fruit on the previous harvest date. Trunk scoring and no N fertilizer were effective for improving fruit blush coloration, and AVG for delaying harvest maturity.

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#### Effect Of AVG and Dormant Oils on Bloom Delay In 'Redhaven' Peach

Anish Malladi\* and Peter M. Hirst, Dept. of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907-1165

Peach production is significantly reduced and severely limited by frost injury in regions frequently exposed to late spring freeze conditions. Peach flower buds become increasingly susceptible to low-temperature damage from the period of completion of rest through fruit set. Delaying dehardening and/or flower bud development is an effective way to avoid frost damage. Bio-regulator applications, affecting dormancy or bud development, can delay flowering and dehardening of the buds and can help in avoiding spring freeze injury. Spring applications of AVG and dormant oils on 8-year-old 'Redhaven' peach trees were evaluated. AVG applications effectively delayed bloom by 2 to 5 days. The most effective treatment was two applications of 2000 ppm AVG, which delayed bloom by almost 5 days. Repeat applications of AVG were more effective than the single dosage treatments. The 1000 ppm, repeat application delayed bloom by 4 days. A single application of 5000 ppm AVG resulted in severe phytotoxicity. The wetting agent levels were also varied and AVG applications were most effective in combination with 0.2% 'Sylgard'. AVG, apparently, delayed bloom by delaying bud development following the completion of rest. The dormant oil sprays were ineffective in achieving bloom delay. The specific leaf weight characteristics of the treated trees were not affected except for the 5000-ppm AVG application, which reduced SLW. Fruit characteristics such as maturity, weight, and soluble sugar concentration were not affected by any of the spring applications (except for the 5000-ppm AVG application, which was phytotoxic). Our studies indicate that AVG is effective in delaying bloom in peaches by up to 5 days. This has the potential to substantially increase peach yields in years with a late spring freeze.

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#### Effects of NAA-800 and Retain on Fruit Retention and Quality of 'Rome Beauty' and 'Delicious' Apples

Esmail Fallah\*<sup>1</sup> and Duane W. Greene<sup>2</sup>, <sup>1</sup>Parma Research and Extension Center, Univ. of Idaho, 29603 U of I Lane, Parma, ID, 83660; <sup>2</sup>Dept. of Plant and Soil Sciences, Univ. of Massachusetts, Box 37245, Amherst, MA 01003

Effects of various combinations of NAA-800 and Retain on fruit retention, yield, and harvest and post-storage fruit quality of 'Rome Beauty' and 'Delicious' apples were studied over one to three seasons. Retain and NAA-800 often reduced preharvest fruit drop as compared to control. Fruit from trees that received Retain at 123.6 g a.i./ha, or 61.8 g a.i./ha plus NAA-800 showed lower starch degradation pattern (SDP) at harvest and higher firmness. Retain treated fruit had lower evolved ethylene and respiration. Application of Retain at 61.8 g a.i./ha plus NAA-800 delayed fruit maturity, and the effects on fruit quality at harvest was comparable to the effects of this chemical at 123.6 g a.i./ha. However, after storage, fruits from trees receiving Retain at 123.6 g a.i./ha often were firmer. Split applications of NAA-800 did not show major improvement in delaying fruit maturity over a single application. Application of NAA-800 at 585 mL/ha tended to reduce fruit firmness and increase fruit SDP. These fruits some times tended to have better color. Results on fruit color varied from year to year.

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#### The Influence of Reflective Film and ReTain on Red Skin Color and Maturity of 'Gala' Apples in South Carolina

Desmond R. Layne\*<sup>1</sup>, Zhengwang Jiang<sup>1</sup>, and James W. Rushing<sup>2</sup>, <sup>1</sup>Dept. of Horticulture, Clemson Univ., Clemson, SC 29634-0375; <sup>2</sup>Coastal R.E.C., 2865 Savannah Hwy., Charleston, SC 29414

Replicated trials were conducted in summers of 1998 and 1999 at two commercial orchards (A and B) to determine the influence of a metallized, high-density polyethylene reflective film (SonocoRF, Sonoco Products Co., Hartsville, S.C.) and ReTain (Abbott Laboratories, Inc., N. Chicago, Ill.), on fruit red skin color and maturity of 'Gala' apples. There were four experimental treatments: i) Control; ii) Reflective Film (RF); iii) ReTain; and iv) RF + ReTain. RF was laid 4 weeks before anticipated first pick date by laying a 5-ft-wide strip of plastic on either side of the tree row in the middle. ReTain was applied 4 weeks before harvest at the commercial rate in one orchard (A) and at 60% the commercial rate in the other orchard (B). At harvest, two 50-fruit samples were picked from each of four replicate blocks

per treatment. All fruit were sized and visually sorted for color (1 = 0% to 25%, 2 = 26% to 50%, 3 = 51% to 75%, and 4 = 76% to 100% red surface, respectively). A 10-fruit subsample was selected following color sorting and evaluated for puncture pressure, soluble solids concentration (SSC) and starch hydrolysis. ReTain delayed maturity and reduced preharvest drop of 'Gala'. Fruit from RF trees had a significantly greater percent red surface than fruit from trees not treated with RF. Fruit from RF + ReTain were significantly redder and had higher SSC than fruits from trees treated with ReTain alone. There were no differences in size, puncture pressure or starch hydrolysis between RF and RF + ReTain. RF appears to be a means to ensure greater redness in 'Gala' treated with ReTain in South Carolina.

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### The Influence of Reflective Film on Red Skin Color and Maturity of Peaches in South Carolina

Desmond R. Layne<sup>\*1</sup>, Zhengwang Jiang<sup>1</sup>, and James W. Rushing<sup>2</sup>; <sup>1</sup>Dept. of Horticulture, Clemson Univ., Clemson, SC 29634-0375; <sup>2</sup>Coastal R.E.C., 2865 Savannah Hwy., Charleston, SC 29414

Replicated trials were conducted in summers of 1998 and 1999 at several commercial orchards to determine the influence of a metalized, high-density polyethylene reflective film (SonocoRF, Sonoco Products Co., Hartsville, S.C.) on fruit red skin color and maturity of peach cultivars that historically have poor red coloration in South Carolina. At each site there were two experimental treatments: i) Control; and ii) Reflective Film (RF). RF was laid 2 to 4 weeks before anticipated first pick date by laying a 5-ft-wide strip of plastic on either side of the tree row in the middles. Treatment blocks at a given farm ranged from 0.5 to 1 acre in size and each treatment was replicated four times at each site. At harvest, two 50-fruit samples were picked from each block per treatment. All fruit were sized and visually sorted for color (1 = 0% to 25%, 2 = 26% to 50%, 3 = 51% to 75%, and 4 = 76% to 100% red surface, respectively). A 10-fruit subsample was selected following color sorting and evaluated for puncture pressure and soluble solids concentration (SSC). All cultivars tested (CVN1, Loring, Bounty, Summer Gold, Sun Prince, Cresthaven, and Encore) experienced significant increases in percent red surface when RF was used in 1998 and 1999. This color improvement ranged from 16 to 44% (mean = 28%). On average, fruits from RF were 0.8 lb softer and had 0.3% higher SSC than control fruits. Growers harvested more fruit earlier and in fewer picks for RF. Fruit size was not affected by RF. The influence of RF on orchard microclimate and quality and quantity of reflected light will be discussed.

579

### Thinning Nectarines and Peaches at Flowering with Organosilicone Surfactants

Joshua D. Klein<sup>\*1</sup> and Shlomo Cohen<sup>2</sup>; <sup>1</sup>Dept. of Field Crops, Volcani Center, Bet Dagan, Israel; <sup>2</sup>Institute for Agricultural Research according to the Torah, Yad Binyamin, Israel

Thinning of nectarines and peaches is largely an expensive manual task. We investigated the use of organosilicone surfactants as thinning materials that can be applied by mechanized sprayers. Of the surfactants tested, Silwet-408 (Witco) and Boost (Dow-Elanco) were the most effective thinning agents. Spray concentrations of 0.1% or 0.25% (v/v) applied at 30% and 60% full bloom, or 0.5% applied at 80% to 90% bloom, reduced by 50% the mass of fruitlets that had to be hand-thinned and increased the average weight of harvested fruit by up to 20%. When 0.75% to 1% surfactants were applied at 80% to 100% full bloom, fruit yield was reduced by up to 90%. The sprays did not affect fruitlets that had set already, nor did they cause damage to leaves or young shoots. Open flowers were more susceptible to the surfactants than were flowers at tight-bloom or balloon stage. Ion leakage from both petals and flower bases increased in proportion to concentration of surfactant applied, but there was no increase in lipid peroxidation.

580

### GA Application Timing in Fall and Winter Influences Bloom Period, Flowering Intensity, and Final Crop in Florida 'Navel' Orange

E.W. Stover<sup>\*</sup>, S.M. Cillento, and, X. Yang; Indian River Research & Education Center, Univ. of Florida, Ft. Pierce, FL 34945

In Florida's subtropical climate, citrus floral induction is primarily stimulated by cool weather in the fall and winter. Frequently, inductive periods are separated by warm conditions conducive to bud development, resulting in prolonged and multiple bloom. Large variability in date of fruit-set creates an array of problems,

and prolonged bloom contributes to severity of postbloom fruit drop. GA applied during the inductive period inhibits bloom in citrus. This study was conducted to determine whether different GA application timings could shift bloom intensity and duration to reduce problems associated with prolonged bloom. GA was applied via airblast sprayer to mature 'Navel' on sour orange rootstock near Ft. Pierce, Fla., at 49.4 g GA/ha, 0.05% Silwet L-77, and 2340 L/HA spray volume. Six single-tree experimental units per treatment were blocked by size and vigor in a randomized complete block design. Treatments were time of GA application: 23 Nov. 1998; 17 Dec. 1998; 6 Jan. 1999; 25 Jan. 1999; 23 Nov. and 17 Dec.; 23 Nov. and 25 Jan.; 6 Jan. and 25 Jan.; and a control. Bloom began one month earlier on trees that received the two January applications compared to trees that received GA on 23 Nov. and 17 Dec.. Trees sprayed 25 Jan. (or 6 Jan. and 25 Jan.) had 2 weeks shorter bloom duration compared to controls. Total flowering on GA-treated trees ranged from 13% to 55% of the controls. Single GA applications on 17 Dec. and 6 Jan. increased fruit yield at harvest by 42% and 25%, respectively, while GA on 6 and 25 Jan. yielded 27% less than controls. All other timings had no effect on yield.

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## 106 ORAL SESSION 22 (Abstr. 581–585) Viticulture: Crop Production Tuesday, 25 July, 4:00–5:15 p.m

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581

### Effect of CPPU on Fruit Development in Seedless and Seeded Grape Cultivars

T.J. Zabadal<sup>\*</sup> and M.J. Bukovac; Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824

The effect of CPPU [forchlorfenuron; N-(2-chloro-4-pyridinyl)-N-phenylurea] on berry development of selected seedless and seeded grape cultivars was evaluated under field conditions. A concentration response curve was initially established by spraying clusters of 'Himrod' at a mean berry diameter of 5 mm with 0, 5, 10, and 15 ppm CPPU. Berry enlargement was monitored (16, 30, 44, and 59 days after treatment) during development and cluster weight, berry number/cluster, weight, firmness and °Brix were determined at harvest. Berry size was dramatically (2.3 vs. about 3.6 g/berry) increased at harvest by all concentrations of CPPU; the response being linearly related to concentration ( $r^2 = 0.89$ ). Cluster weight and compactness (rated) and berry firmness were significantly increased. There was no significant effect on berry number (79 to 86/cluster). °Brix and rachis necrosis (at harvest) as well as berry abscission after 30 days of refrigerated storage were significantly reduced. Effect of time of CPPU application (0, 5, and 10 ppm) was established by treatment of clusters at mean berry diameters of 4, 5, 7, and 9 mm. Response was indexed by following berry enlargement at 14, 28, 42, and 56 (maturity) days after treatment. Maximum berry enlargement for both 5 and 10 ppm was obtained from applications at 4 to 7 mm in diameter. Relative responsiveness of seedless and seeded cultivars was compared by application of CPPU at 0, 5, 10, and 15 ppm to clusters (4–6 mm berry diameter) of seedless 'Himrod', 'Vanessa' and 'Lakemont' and seeded 'Concord' and 'Niagara'. Bioresponse was determined by a time course of berry enlargement and berry and cluster weight, number of berries/cluster and rating cluster compactness at maturity. CPPU at all concentrations increased seedless berry diameter significantly from the first measurement at 14 days through 56 days after maturity. Berry and cluster weight and cluster compactness were increased in the seedless cultivars, although 'Lakemont' appeared less responsive than 'Himrod' and 'Vanessa'. CPPU did not change ('Lakemont') or decrease ('Himrod', 'Vanessa') berries/cluster. In contrast, the only effect of CPPU on the seeded cultivars was an initial increase in berry diameter 14 days after application.

582

### Maintenance of Fruiting Potential through the Winter for Merlot Grapevines Grown in Southwestern Michigan

Thomas J. Zabadal<sup>\*</sup> and Thomas Dittmer; Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824

Producing the cold-tender wine grape Merlot is a major challenge in the cool-climate viticultural region of southwestern Michigan. Merlot grapes produced in this region provide a strong market opportunity; therefore, several strategies for



preserving the fruiting potential of vines through the winter were evaluated over 5 years. Vines were managed with frequent trunk renewal so that they were pliable and capable of being laid near the ground. One treatment was (A) a control. Three treatments involved pruning vines in the late fall to two to four canes, which were then (B) laid on the ground without any cover, (C) attached to a wire near the ground and covered with straw, or (D) attached to a wire near the ground and covered with 20 cm of soil. The fifth treatment (E) involved arching unpruned vines to place canes near the ground but without any covering. Pruning was completed in spring, and vines were tied using fan training. Vines were adjusted to a maximum of 40 live nodes per vine. Winter minimum temperatures averaged 1, 8 and 16 °C warmer than the air temperature at 1.5 m above ground when measured at 0.3 m above ground (B and E), under the straw mulch (C), and under the soil (D), respectively. Very low ambient air temperatures of -27 and -28 °C were experienced in two of the winter periods. C, D, and E consistently provided greater node survival through the winter than control vines. B was inconsistent in performance. The lowest annual yields for A through E for the 5-year period were 3.1, 0.7, 8.3, 6.7, and 9.0 tons per hectare, respectively. These data indicate that treatments C, D, and E were capable of reliable annual production of Merlot grapes even in years with episodes of low winter temperatures. Projects are under way to develop commercial capability for the vine burial and mulching techniques used in this study.

### 583

#### Scaling-up Heat-balance Sap Flow Sensors for the High Flow Rates of Mature Grape Vines

J.M. Tarara\* and J.C. Ferguson; U.S. Dept. of Agriculture, Agricultural Research Service, 24106 N. Bunn Rd., Prosser, WA 99350

Management strategies like "deficit irrigation" in wine grapes require accurate, reliable information on vine water use, making direct measurements of vine transpiration highly desirable. The heat-balance sap flow method has the advantages of being non-invasive and requiring no other calibration beyond a zero-flow set. Potential violations of the method's assumptions were dealt with and the heat balance method successfully applied to mature grape vines under conditions of extremely high sap flow. Greenhouse studies suggested that vines transpire at night, up to 9.5% of the total 24-h water loss, thus violating the zero-flow assumption for setting the gauge constant. Using a predetermined gauge constant caused smaller errors than using daily, pre-dawn constants set in situ. The steady-state assumption was violated only in early and late hours of the day, and the inclusion of a term to account for the change in heat stored by the stem only marginally improved daily estimates of water use. The assumption of radially uniform temperature across the heated stem segment is violated at very high flows (e.g., >700 g·h<sup>-1</sup>), but can be corrected for by using wider heaters and adjusting the placement of thermocouples. For a mature, potted vine in the greenhouse, the maximum absolute error in cumulative daytime water use between a sap gauge and a precision load cell was about -10%, with the gauge almost exclusively underestimating water loss. A custom-built, 20-gauge system was run continuously in the field for 90 days. Vine-to-vine variability in water use was not accounted for by normalizing sap flow by leaf area, suggesting that it is critical to include in any field study the largest number of gauges that are technically feasible.

### 584

#### Cover Crop Evaluations for Eastern Washington Vineyards

Mercy A. Neumann<sup>1</sup>, Robert L. Wample<sup>1</sup>, Julie Tarara<sup>2</sup>, and Stephanie Greene<sup>2</sup>, <sup>1</sup>IAREC, Washington State University, Prosser, WA 99350; <sup>2</sup>USDA/ARS, Prosser, WA 99350

The location of the Columbia and Yakima valleys present vineyard managers in eastern Washington with significant concerns, particularly low rainfall and wind erosion. Cover crops, as part of a complete management system, can reduce the effects of wind erosion in vineyards by stabilizing soil particles and reducing runoff. Cover crops also reduce weed biomass. During research conducted at Prosser, Wash., 175 foreign and domestic species were assessed for performance as cover crops. Using a screening process, nine species were chosen for evaluation in large commercial plots. Grass species included cereal rye, crested wheatgrass, Sherman Big Blue wheatgrass, perennial rye, pubescent wheatgrass, and three fescues. Legume species included two annual clovers (*Trifolium* spp.) and two reseeding annual medics (*Medicago* spp.). Unseeded, resident vegetation served as a control. Vine and soil water statuses were monitored regularly. Initial establishment of all species was delayed because of low rainfall throughout the growing season; thus performance varied for each species. Drought-tolerant grass

species had better germination and establishment than legumes, due to planting method. In-row water status and vine water potentials remained constant throughout the main portion of the growing season. A mix of crested wheatgrass, perennial rye, and pubescent wheatgrass (Canada mix) gave especially good cover without affecting vine or soil water status. Weed biomass was reduced in most cases, with legumes having least effect; cereal rye, crested wheatgrass and the Canada mix had the greatest effect. Season-long suppression was best achieved with the Canada mix because of the nature of establishment. In this study, most drought-tolerant grasses performed better than legumes; however, with proper establishment, legumes can be a beneficial part of a sustainable agriculture system.

### 585

#### Rooting Hardwood Cuttings of *Vitis aestivalis* 'Norton'

Kathryn Keeley\* and John E. Preece; Department of Plant, Soil and General Agriculture, Southern Illinois University, Carbondale, IL 62901-4415

Hard-to-root hardwood cuttings of *Vitis aestivalis* 'Norton' were collected during Feb. 1999. Cuttings had three nodes and were 10 to 15 cm long. Prior to treatments, cuttings were submersed in a solution of 9.5 g/1L of ZeroTol (a mixture of hydrogen dioxide and peroxyacetic acid). The bottom two nodes were placed into 1 vermiculite : 1 perlite (by volume) and set under mist in the greenhouse at of 20/15 °C day/night). About 5 weeks after treatment, number of roots and root length data were collected. The bottom 2 cm of cuttings in one experiment received a 30-s dip in 0, 2500, 5000, 7500, or 10,000 mg/L IBA and/or NAA to determine the effects of these treatments on rooting of hardwood cuttings. IBA and NAA are not significantly different, however there was a positive linear relationship between rooting and concentration of auxin. As concentration of auxin increased, mean number of roots increased. In additional experiments, cuttings treated with 0 or 5000 mg/L of IBA were compared based on timing after harvest of cuttings and treatment. Of the cuttings treated and placed under mist on 26 Mar. 1999, 30% of the control cuttings rooted and 50% of the cuttings treated with 5000 mg/L rooted. Two weeks later, 65% and 55% of the cuttings treated with 5000 mg/L rooted respectively to the 0- and 5000-mg/L treatments. One week later (14 Apr. 1999), 77.5% and 72.5%, respectively, rooted. This suggests that timing after harvest for placing the cuttings in a propagation bed is important for increasing the rooting percentage of 'Norton' hardwood cuttings.

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## 107 ORAL SESSION 23 (Abstr. 586-593)

### Vegetable Crops: Crop Physiology

Tuesday, 25 July, 4:00-6:00 p.m

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### 586

#### Cell Wall Protein Differences in Fruits of Two Tabasco Pepper Lines

Ramon A. Arancibia\* and Carl E. Motesbocker; Department of Horticulture, LSU AgCenter, Baton Rouge, LA 70803

'McIlhenny Select' (easy detachment) and 'Hard Pick' are two lines of tabasco pepper (*Capsicum frutescens* L.) that differ in the fruit detachment characteristics. Cellulase (Cx) and polygalacturonase (PG) activity, extracted from the fruit abscission zone, correlated inversely with the force needed to separate the fruit from the pedicel. A trend of higher Cx and PG is associated with the lower detachment force in the McIlhenny Select line. Differences in the fruit cell wall protein profile between both lines occurred during ripening. Two bands of 23 kDa and 40 kDa were higher in 'McIlhenny Select'. A band of approximately 30 kDa was higher in 'Hard Pick', while a band of ≈70 kDa increased in both lines. Isolation and characterization of these bands as well as Cx and PG is needed to understand the factors affecting fruit detachment in tabasco pepper.

### 587

#### Physiological Factors Limiting Tomato Fruitset at Moderately Elevated Temperatures

M.M. Pee\*<sup>1</sup> and S. Sato<sup>2</sup>; Depts. of <sup>1</sup>Horticultural Science and <sup>2</sup>Crop Science, North Carolina State Univ., Raleigh, NC 27695-7609

The effects of chronic, mild heat stress on fruit set, fruit production, release of pollen grains, photosynthesis, night respiration, and anther dehiscence were ex-

amined in tomatoes (*Lycopersicon esculentum* Mill.) differing in high temperature sensitivity. Plants were grown under three temperature regimes: 1) 28/22 or 26/22 °C (optimal temperature) 2) 32/26 °C (high temperature), and 3) 32/26 °C day/night temperatures relieved at 28/22 °C for 10 days before anthesis, then returned to 32/26 °C (relieving treatment). 'FLA 7156' was the only cultivar with fruit set at 32/26 °C. All five cultivars, however, had fruit set in the relieving treatment (RT). The longer the relief, the higher was the percentage of fruit set. Longer periods of relief also increased the number of pollen grains released and linear regression analysis showed a significant relationship between the number of pollen grains released and the percentage of fruit set. Germination of pollen grains was also lowered in high-temperature-grown plants. The number of pollen grains produced, photosynthesis, and night respiration did not limit fruit set under chronic, mild heat stress, however. This suggested that cultivar differences in ability to release pollen and to produce viable pollen under heat stress are the most important factors determining their ability to set fruit.

588

### Moisture Balance in Dry-heat-treated Vegetable Seeds

Jung-Myung Lee<sup>1</sup> and Du-Hyun Kim; Dept. of Horticulture, Kyung Hee Univ., Suwon, Republic of Korea 449-701

Dry-heat (DH) treatment has been extensively used for inactivation of some seed-borne virus and *Fusarium* disease in many vegetable crops, especially in cucurbitaceous vegetables. Strains of tobamovirus (cucumber green mottle mosaic virus; CGMMV) could be successfully inactivated by treating the infected seeds at 75 °C for 72 h. However, DH-treated seeds frequently exhibit slow and poor germination and abnormal seedling characteristics, such as distorted, white streaked, and punctured cotyledons in the seedlings. The moisture content in seed coat and inner cotyledons fell down to below 1% in DH-treated seeds when treated at 75 °C or higher. However, when the seeds were treated at 65 °C, final moisture content in the DH-treated seeds were maintained at about 2.5% to 3.5%. Seeds absorbed moisture above 20% at 100% RH, 9% to 10% at 73% RH, and 4% to 5% at 28% RH, respectively. When the intact and DH-treated seeds were exposed to conditions of varying relative humidity, DH-treated seeds absorbed atmospheric moisture at a much slower rate than the intact seeds in all tested cultivars, and this is thought to be one of the major reasons for slower germination in DH-treated seeds. The inactivation of virus, comparison of respiration of seeds, and endogenous gibberellic acid contents will also be presented.

589

### Calcium Application at Preemergence and during Bulking May Improve Tuber Quality and Grade

Christopher Gunter<sup>1</sup>, Senay Ozgen, Bjorn Karlsson, and Jiwan Palta; Department of Horticulture, University of Wisconsin, 1575 Linden Dr., Madison, WI 53706

An increase in calcium concentration of potato tuber tissue has been shown to reduce soft rot severity and the incidence of internal physiological defects. Higher tuber calcium also seems to increase sprout vigor and maintain apical dominance by reducing subapical necrosis and sprout tip death. Preemergent applications of calcium at a rate of 0 and 26.5 kg·ha<sup>-1</sup> from ammonium nitrate (PreAmNit), ammonium nitrate plus calcium nitrate (PreCaN), or calcium chloride plus calcium nitrate plus urea (PreCUC). A group of post-emergent split calcium nitrate plus calcium chloride plus urea (PostCUC) applications beginning with hilling and proceeding at 3, 6, and 8 weeks after hilling were also made at a rate of 56 kg·ha<sup>-1</sup> calcium at each application time. From visual ratings of stand quality taken 64 days after hilling, we found plants receiving a preemergent application of nutrients or PostCUC had higher stand ratings than paired control plots. Internal tuber quality ratings revealed less internal brown spot in the PostCUC application in 168–364-g tubers. Yield of 112–168-g tubers was greatest from plants treated with PreCaN or PreCUC followed by PostCUC. PreAmNit plots had higher culms than the PreCUC plots. The non-split ammonium nitrate control (all nitrogen by hilling) produced a higher number of B-sized tubers than the PostCUC treatment. Also the PreAmNit+PostCUC had more B-sized tubers than PreCaN+PostCUC. In general the PostCUC treatment produced fewer small tubers and more large tubers than other treatments. These results suggest application of a small amount of calcium prior to emergence but after the sprouts have begun to develop improves seed performance. Furthermore these data show that supplemental calcium application during the season may improve tuber grade.

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### Supplemental Application of Calcium and Nitrogen Improves Internal Quality of 'Russet Burbank' Potatoes

Senay Ozgen<sup>1</sup>, Christopher Gunter, Bjorn Karlsson, and Jiwan Palta; Dept. of Horticulture, Univ. of Wisconsin, Madison, WI 53706

Potato tuber tissue is calcium-deficient. Consequently, increasing Ca concentration is desirable to improve tuber quality. The purpose of the present study was to determine the influence of supplemental Ca and N fertilization on internal quality of potato. Three products (calcium nitrate, calcium chloride, and gypsum) were used to increase tuber calcium concentration. We tested combinations of both soluble sources of calcium and gypsum. Each treatment had five replications and received same total amount of N, supplied either from ammonium nitrate, liquid N (UAN: 50% urea + 50% ammonium nitrate) and calcium nitrate or combination of these sources (at rate of 225 kg·ha<sup>-1</sup>). The total Ca was applied at the rate of 168 kg·ha<sup>-1</sup>. Application of N at emergence and hilling (nonsplit) was compared to split application of N and Ca at hilling, 2, 4, and 6 weeks after hilling. At harvest, ≈100 tubers from each replication were cut in half along longitudinal axis and visually inspected for internal defect in both years. Application of Ca, especially in split schedule and from soluble sources, significantly increased tuber tissue Ca concentration. In 1998, the incidences of hollow heart (HH) and internal brown spots (IBS) were very low. The treatment containing calcium nitrate and calcium chloride combination produced the lowest total defects, whereas application of gypsum was not effective at reducing defects. In 1999, application of all Ca sources including gypsum, reduced HH and IBS. Data from these studies suggest that tuber calcium level is increased by field applications of moderate amount of Ca and tuber quality is impacted by N and Ca application. Furthermore, seasonal climatic variations appear to have dramatic influence on the incidence of internal defects in potato tubers.

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### MelonMan: A Simple Phenology Model of Muskmelon Development

J.T. Baker<sup>1</sup>, D.I. Leskovaar<sup>2</sup>, V.R. Reddy<sup>1</sup>, and F.J. Dainello<sup>3</sup>; <sup>1</sup>Remote Sensing and Modeling Lab., USDA-ARS, Bldg. 007, Rm. 008, 10300 Baltimore Ave., Beltsville, MD 20705; <sup>2</sup>Dept. of Horticultural Sciences, Texas Agricultural Experiment Station, Texas A&M Univ. Agricultural Research and Extension Center, 1619 Garner Field Rd., Uvalde, TX 78801; <sup>3</sup>Dept. of Horticultural Sciences, Texas Agricultural Extension Service, Texas A&M Univ., College Station, TX 77843

A temperature experiment with two cultivars of muskmelon ('Gold Rush' and 'Mission') was conducted in growth chambers to determine how main vine leaf appearance rates responded to temperature. We identified three cardinal temperatures for leaf appearance rate: the base temperature (10 °C) at which leaf appearance rate was zero, an optimum temperature where leaf appearance rate was at a maximum (34 °C) and an upper threshold temperature (45 °C) where leaf appearance rate returned to zero. Using these three cardinal temperatures, we constructed a simplified thermal unit accumulator for hourly measurements of air temperature. Main vine plastochron interval (PI), thermal time to harvest and final yield was determined for three cultivars of muskmelon ('Explorer', 'Goldrush', and 'Mission') grown in the field over six transplanting dates. The PI was calculated for each cultivar-transplanting date combination as the reciprocal of the slope of main vine node number vs. accumulated hourly thermal units (Tu). The PI was significantly affected by both cultivar and transplanting date. Final yield was sharply reduced in the last two planting dates, presumably due to high temperature stresses impacting reproductive development. As air temperatures warmed during the field experiment, the time interval from transplanting to 10% final harvest were reduced by between 21 to 28 days among the three cultivars and the first four transplanting dates. Our goal was to construct a simple muskmelon phenology model that could be run with easily obtainable weather station data and used by growers to quantify phenological development and aid in projecting harvest dates. We also wanted to test whether main vine node number was a useful description of vegetative development for muskmelon.

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### Water Flux from Lettuce Plants at Reduced Atmospheric Pressure

Kenneth A. Corey<sup>1</sup>, Phil A. Fowler<sup>2</sup>, and Raymond M. Wheeler<sup>3</sup>; <sup>1</sup>Dept. of Plant & Soil Sciences, University of Massachusetts, Amherst, MA 01003; <sup>2</sup>Dynamac Corporation, Kennedy Space Center, FL 32899; <sup>3</sup>National Aeronautics and Space Administration, Kennedy Space Center, FL 32899

Reduced atmospheric pressures may be used to minimize mass and engineering requirements for plant growth habitats used in some extraterrestrial applications. A chamber with high vacuum capability and thermal control at Kennedy Space Center was used to measure water loss of lettuce plants at reduced atmospheric pressures. A test stand with three, high-pressure sodium vapor lamps was used to determine short-term plant responses to reduced pressure. Initial experiments with lettuce showed that a pressure of 10 kPa ( $\approx 0.1$  atm) resulted in a 6.1-fold increase in the rate of water loss compared to water loss at ambient pressure. However, due to low relative humidity, plants wilted after 30 minutes exposure to 10 kPa. A follow-up experiment in which relative humidity was controlled between 70% and 85%, demonstrated that water loss was directly proportional to the vapor pressure gradient, regardless of atmospheric pressure in the pressure range of 10 to 101 kPa. However, the response was curvilinear, suggesting effects on the pathway resistance. Results indicate that plant growth at atmospheric pressures of 5 to 10 kPa should be achievable. Further work will necessitate better relative humidity control and carbon dioxide control in order to separate vapor pressure deficit effects from diffusion effects.

593

### A Lightweight, Hand-operated Pressure Chamber for Determining Plant Water Status

Ken Shackel\* and David Paige; Dept. of Pomology, Univ. of California, One Shields Ave., Davis, CA 95616-8683

In a number of tree crops, we have found that the water potential of lower canopy, nontranspiring leaves, measured with the pressure chamber at midday (midday stem water potential), is an excellent index of plant water stress and can be used for irrigation scheduling. Because stem water potential is typically much higher than transpiring leaf water potential, a lower pressure is required for the measurement, allowing us to design and build a lightweight device that could be easily operated by hand. The prototype was designed for pressures up to 2 MPa, which is sufficient for most irrigation conditions. A number of design features were incorporated into the sealing gland to eliminate the need for retightening during the pressurization process, reduce the amount of tissue external to the pressure chamber, and allow a greater visibility of the petiole. Identical values to those obtained with the standard, compressed nitrogen pressure chamber were obtained over the entire 2-MPa range, and the time required using either device under field conditions was the same (about 1 min per measurement). A number of alternative protocols were tested, and we found that even substantial recutting of the petiole had no influence on the measured water potential, contrary to popular belief. We also found that the same sample could be remeasured multiple times (five), with no net change in the water potential, allowing the measurement to be checked if necessary. This device should be of great utility in field irrigation management.

## 108 ORAL SESSION 24 (Abstr. 594–601)

### Fruits/Nuts: Crop Production

Tuesday, 25 July, 4:00–6:00 p.m

594

### Citrus Rootstocks Affect Scion Nutrition, Fruit Quality, Growth, Yield, and Economical Return

Mongi Zekri\*; Univ. of Florida, IFAS, Hendry County Extension Office, P.O. Box 68, LaBelle, FL 33975-0068

Since the environmental conditions and cultural practices are unique in southwest Florida, a study was performed to determine the horticultural adaptability and performance of 'Valencia' orange trees on four commercial rootstocks grown in a high-density planting. The trees were planted in 1991 on a flatwoods soil in a commercial grove at a density of 627 trees/ha. Leaf mineral concentration, growth, and fruit production and quality were measured 4 and 7 years after planting. Compared

to Florida citrus leaf standards, leaf mineral concentration values were within the optimum to the high range. Yield efficiency expressed as kilograms of solids per cubed meter of canopy and juice quality in terms of juice content, soluble solids concentration, and kilograms of solids per box increased with tree age. Tree and fruit size were the highest for Volkamer lemon (Volk) and the lowest for Cleopatra mandarin (Cleo). Fruit yield was the highest for Volk. However, yield expressed in kilograms of solids per hectare was not significantly different between Volk and 'Swingle' citrumelo (Swi) due to the higher solids per box for Swi. Yield efficiency was also higher for Swi than for Volk. Juice content and soluble solids in the fruit were higher for Swi and Cleo than for the lemon rootstocks. Financial analysis showed that at high-density planting, trees on Swi were the most profitable. On noncalcareous flatwoods soil, Swi is the best suited rootstock for high-density planting.

595

### Computer Root Image Analysis of Citrus Rootstock Seedlings

Milton E. Tignor\* and Peter J. Stoffella; Horticultural Sciences Department, Indian River Research and Education Center, Institute of Food and Agricultural Sciences, University of Florida, Fort Pierce, FL 34945-3138

Florida citrus has had an average annual on-tree value of  $\approx 1$  billion dollars during the past decade in Florida. Nearly all of the 845,260 acres of citrus in Florida is produced on grafted trees consisting of a commercial scion cultivar and a rootstock selected specifically for local soil, environment, and pest pressures. With vastly different root-zone environments, ranging from deep sands to drained and cleared pine Flatwoods, a large number of different rootstocks are utilized. These rootstocks are started from seed at more than 100 commercial nurseries statewide, which currently produce an estimated 6 million trees a year. Although the optimum germination conditions, basic physiological performance, and adaptability of many rootstocks are known, there has been minimal investigation on early root development in seedling trays at the nursery. Four hundred seedlings of 'Swingle' citrumelo (*Citrus paradisi* Macf. 'Dunac' X *Poncirus trifoliata*), 'Smooth Flat Seville', 'Volkamer' lemon (*Citrus volkameriana*), and 'Sun Chu Sha' mandarin were seeded in a randomized block experimental design and grown at a commercial nursery. Seedling root systems (100/rootstock) were analyzed for a number of variables using the Rhizo (Regent Instruments, Inc.) software package and a dual light source scanner. Using the SAS general linear model procedure, hypothesis testing revealed rootstock selection had a significant effect on total root length, total root surface area, total root volume, number of root tips, number of root forks, root dry weight, and stem diameter. For most characteristics, rootstock genotype accounted for a greater portion of variability than samples (plant to plant variability).

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### Location and Rootstock Effects on Sheepnosing in Grapefruit

Bhimanagouda S. Patil\*; Texas A&M University-Kingsville, Citrus Center, P.O. Box 1150, Weslaco, TX 78599-1150

Two-year field studies at three sites in the Lower Rio Grande Valley of Texas were conducted to evaluate the effects of location, rootstock, and irrigation on sheepnosing of 'Rio Red' grapefruit (*Citrus paradisi* Macf.) on sour orange (*Citrus aurantium* L.) rootstock. Based on the equatorial/polar diameter ratio, grapefruit grown in Weslaco had significantly higher percentage of sheepnosed fruits (62.66) than fruit grown in Mission (57.32), while Bayview had a negligible percentage of sheepnosed fruit (4.07). In a second study, 'Rio Red' grapefruit grown on Carrizo [*C. sinensis* (L.) Osbeck x *Poncirus trifoliata* (L.) Raf.] had significantly higher percentage of sheepnosed fruit (59.46), compared to 'Rio Red' grown on Swingle (*C. paradisi* x *P. trifoliata*) (47.83). In a third experiment, grapefruit with microjet irrigation had a significantly higher percentage of sheepnosed fruit (53.40), compared to flood irrigation (42.68). Although sheepnosed fruit had significantly greater peel thickness and a lower juice content, fruit quality was better because of higher soluble solids: titratable acidity ratio compared to normal shaped fruits. While significant, the irrigation and rootstock appear have a minor effect on sheepnosing less than growing location.

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### Rootstock and Scion Interact to Affect Apple Tree Performance: Results from a 10-year Trial by the NC-140 Technical Committee

Wesley R. Autio\*; Department of Plant & Soil Sciences, University of Massachusetts, Amherst, MA 01003

In 1990, trials were established at 13 sites including 'Golden Delicious',

'Jonagold', 'Empire', and 'Rome' apple cultivars in all combinations on M.9 EMLA, B.9, Mark, O.3, and M.26 EMLA rootstocks. After 10 growing seasons, rootstock and cultivar interacted significantly to affect trunk cross-sectional area and yield efficiency but not yield per tree or survival. Generally, trunk cross-sectional area was greatest for M.26 EMLA, followed by O.3, M.9 EMLA, B.9, and Mark. However, differences between B.9 and Mark and between M.9 EMLA and O.3 varied with cultivar. B.9 was 34% to 46% larger than Mark with 'Golden Delicious' and 'Empire,' but they were similar for 'Jonagold' and 'Rome.' O.3 was 27% larger than M.9 EMLA with 'Golden Delicious' and 'Empire,' they were similar for 'Rome,' and O.3 was 12% smaller than M.9 EMLA with 'Jonagold'. M.26 EMLA resulted in the greatest cumulative yield per tree, followed by O.3, M.9 EMLA, B.9, and Mark. Generally, cumulative yield efficiency (1992–99) was greatest B.9 and Mark and least for M.26 EMLA. M.9 EMLA and O.3 were similar and intermediately efficient. However, differences between B.9 and Mark and between M.9 EMLA and O.3 varied with cultivar. M.9 EMLA and O.3 were similarly efficient with 'Golden Delicious', 'Jonagold', and 'Rome,' but M.9 EMLA was 11% more efficient than O.3 with 'Empire'. B.9 and Mark were similarly efficient with 'Golden Delicious' and 'Jonagold', but Mark was 15% more efficient and 25% less efficient than B.9 trees with 'Empire' and 'Rome', respectively. Site played an important role, but survival was best for B.9 and poorest for O.3. Cooperators included: J.L. Anderson, W. Aultio, J. Barden, G. Brown, R. Crassweller, P. Domoto, A. Erb, D. Ferree, A. Gaus, R. Hayden, P. Hirst, F. Morrison, C. Mullins, J. Schupp, and L. Tukey.

598

### Response of Apple Rootstocks to Soil Compaction

David C. Ferree<sup>1</sup>; Horticulture and Crop Science, Ohio State University/OARDC, Wooster, OH 44691, USA

Container-grown apple trees on a range of rootstocks were exposed to different levels of soil compaction created by changing soil bulk density. In 1998, with soil bulk densities of 1.0, 1.2, and 1.4, there was no interaction of rootstock and soil compaction for shoot growth of 'Melrose' trees on 7 rootstocks. However, in 1999, with soil bulk densities of 1.0 and 1.5, a significant interaction on shoot growth did occur with six rootstocks. Shoot length of trees on M.9, M.7, and G.30 were less influenced than G.16, M.26 and MM.106. A bulk density of 1.5 caused a decrease in dry weight of shoots, leaves, and roots of trees on all rootstocks. Compacted soil resulted in a decrease in leaf concentration of K and B and an increase in Mg and Mn.

599

### Evaluation of Two Methods for Estimating Average Fruit Weight for Apple Trees

Richard P. Marini<sup>1</sup>; Department of Horticulture, Virginia Tech., Blacksburg, VA 24061

Average fruit weight from two apple-thinning experiments was estimated by sampling 20-fruit/tree or harvesting all fruit on three branches/tree. The estimated values were compared with the true average fruit weight calculated from the entire crop on a tree. The value of a fruit was calculated from packout data obtained from the two sampling methods and was compared to the true value obtained from the entire tree. Statistical techniques, typically used by biometrists in medical research, were used to assess the agreement between the values obtained with the estimation methods and the true values. Estimates of average fruit weight obtained from 20-fruit/tree may differ from the true value by about 13% and estimates obtained from weighing all fruit on three limbs/tree may be within about 11% to 19% of the true mean. Estimates of fruit value obtained from a 20-fruit sample may differ from the true value by about 4 cents per fruit and estimates from three limbs/tree may differ from the true mean by about 7 cents per fruit. Analysis of variance was performed on each data set and the resulting *P* values differed for the three methods of estimating fruit weight and fruit value. Thus, erroneous conclusions may result from experiments where fruit weight and fruit value is estimated from relatively small samples.

600

### Maintaining Yields In Hedgerow Almond Production

J.P. Edstrom<sup>1</sup>, J. Connell, W. Krueger, W. Reil, J. Hasey, and J. Yeager; University of California Cooperative Extension, Colusa, CA 95932

Four tree training methods have been evaluated since 1979 in California for their affect on yield of "Nonpareil" cvt. almond [*Prunus dulcis* (Mill.) D.A. Webb] in a tightly spaced "Nonpareil"/"Price" cvts 1:1 hedgerow planting. Four variations of open center training began at the first dormant pruning in a 2.2 x 6.7-m

spacing (667 trees/ha): 1) Temporary Hedge—trees trained to three primary scaffolds, standard pruned with alternate trees gradually whisked back to allow space for permanent trees and then removed at 8th year leaving 4.4 x 6.7-m spacing (333 trees/ha); 2) Permanent Hedge—trees trained to three scaffolds, standard pruned at 2.2-m spacing; 3) Two-Scaffold Hedge—Trees trained into "perpendicular V" two scaffold configuration, standard pruned at 2.2-m spacing; 4) Unpruned Hedge—Trained to three scaffolds then left essentially unpruned at 2.2-m spacing. Replicated yield data accumulated over 15 years shows no difference in production between the three permanent 2.2-m hedgerow methods. Yield for the Temporary Hedge, however, declined 30% the year following alternate tree removal. Adequate canopy expansion resulted in some regained nut production, but yields never recovered and remain 20% below the permanent hedge treatments 13 years post-removal. Observations indicate considerable loss of fruitwood has occurred in the lower canopy of all three 2.2-m hedge treatments, especially in the Unpruned but good commercial production has been maintained at 2400 to 3000 kg/ha. The size of almond kernels was not affected by training method. Trunk circumference was affected by treatment. Trees in Temporary Hedge plots grew substantially larger after alternate tree removal than trees in all 2.2-m hedge treatments that were equal in size.

601

### Development of Cultural Methods for Beach Plum (*Prunus maritima* Marsh.) Fruit Production

Richard H. Uva<sup>1</sup>, Thomas H. Whitlow<sup>1</sup>, and William F. Clark<sup>2</sup>; <sup>1</sup>Dept. of Floriculture and Ornamental Horticulture, Cornell Univ., Ithaca, NY 14853; <sup>2</sup>Cape Cod Cooperative Extension, Deeds and Probate Bldg., PO Box 367, Barnstable, MA 02360

Beach plum is a shrub native to Atlantic coastal sand dunes from Maine to Maryland, where it is subject to drought and low nutrient and water holding soil. Since colonial times beach plum fruit has been collected from the wild for the production of preserves, an activity that endures today as a cultural tradition and cottage industry. Currently, the supply of fruit from wild stands does not meet the market's demand; hence, beach plum could be a new crop for many growers in the Northeastern U.S. For the past 4 years, a partnership of growers, Univ. of Massachusetts Extension, and Cornell Univ. has experimented with standard orchard cultural methods for beach plum production in coastal Massachusetts. During Aug. 1999, we harvested the first crop from our experimental orchard. The factorial experiment evaluates the effects of irrigation, mulch, and fertilizer on growth and yield of beach plum. Basal and axial growth were strongly correlated and were greater in fertilized than unfertilized treatments. Within fertilizer regime irrigation and mulch had less effect on growth than fertilizer. Fruit yield (dry weight and fresh weight) was greater in fertilized plots. Irrigation had no positive influence on yield. Average fruit diameter and °Brix were greater in the fertilized and unirrigated treatments.

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## 136 ORAL SESSION 25 (Abstr. 602–606) Small Fruit/Viticulture: Genetics/Breeding/Biotechnology Wednesday, 26 July, 10:00–11:30 a.m.

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602

### Sequencing and Characterizing Blueberry (*Vaccinium* section *Cyanococcus*) Dehydrins

Ganesh R. Pant<sup>1</sup>, Mark W. Rieger<sup>2</sup>, and Lisa J. Rowland<sup>3</sup>; <sup>1</sup>Dept. of Biological Sciences, The George Washington Univ., Washington, DC 20052; <sup>2</sup>Dept. of Horticulture, Univ. of Georgia, Athens, GA 30602; <sup>3</sup>USDA-ARS, Fruit Laboratory, Beltsville Agricultural Research Center, Beltsville, MD 20705

The blueberry industry experiences significant losses every year due to environmental factors with a dehydrative component, such as drought and freezing stress. In a recent survey of blueberry research and extension scientists in the United States, lack of cold hardiness and susceptibility to spring frosts were identified as the most important genetic limitations of current cultivars. For these reasons, cloning and characterization of expression of dehydration-responsive genes (dehydrins) have been ongoing in our laboratory. To date, one full-length (2.0 kb bbdh1 gene) and four partial-length dehydrin cDNAs have been cloned

and sequenced. Very high homology at the DNA and protein levels were found among the blueberry dehydrin clones, particularly at the 3' ends. From DNA blots, it appears that blueberry dehydrins are encoded by about three genes with high homology to the full-length 2.0 kb *bbdhn1* cDNA clone and a few other less related genes. The 2.0 kb *bbdhn1* gene was mapped in a blueberry population segregating for cold hardiness and chilling requirement. Expression studies indicated that dehydrins are induced by cold and drought stress. In general, dehydrins were induced in all organs examined in response to cold stress, including floral buds, leaves, stems, and roots. Under drought conditions, dehydrins were induced primarily in stems and their levels declined in roots. Some of the induced dehydrins were the same for drought and cold stress, whereas others were unique to a given stress. Levels of dehydrin accumulation correlated positively with cold hardiness; however, levels of dehydrins did not correspond precisely to the degree of drought avoidance.

603

### Phenology of Flowering and Leafing in Florida Cultivated Blueberries

Paul Lyrene\*, Horticultural Sciences Dept., Univ. of Florida, Gainesville, FL 32611

The best time to harvest fresh blueberries in Florida is 1 April to 15 May. Weather during this period is normally favorable for harvest: low rainfall, low humidity, warm, sunny days, and cool nights, and supplies of fresh blueberries from other producing areas are low. To ripen high-quality blueberries in April, the plants must flower in February and must have a full canopy of leaves to support the developing crop in March and April. Observations of thousands of blueberry seedlings and selections over the past 25 years in Florida have indicated that blooming and leafing time are affected by the chilling requirement and heat requirement of the variety and also by environmental factors. Factors that increase plant vigor (high soil fertility, ample moisture, and young plants) cause the plants to flower earlier in the spring. Flower buds that do not open by 15 Mar. in north Florida frequently abort. The timing and extent of this physiological bud abortion varies with cultivar. Some southern highbush cultivars leaf before they flower. Others flower before they leaf. The ideal blueberry variety for north Florida would have a very low chill requirement, a high heat requirement to prevent January flowering, and a short flowering-to-ripening interval.

604

### Interspecific Hybridization between *Euvitis* and *Muscadinia* Grape Species

Jiang Lu\*<sup>1</sup> and Bernard Prins<sup>2</sup>; <sup>1</sup>Center for Viticultural Science, Florida A&M Univ., Tallahassee, FL 32307; <sup>2</sup>National Clonal Germplasm Repository, USDA-ARS, Univ. of California

The grape belongs to the genus *Vitis* L., which are divided into two subgenera, *Euvitis* Planch. and *Muscadinia* Planch. The *Euvitis* has 50 to 70 species, in which *V. vinifera* L. is a predominant species with hundreds of known commercial cultivars grown world wide. The *Muscadinia* (muscadine grapes) consists of only two to three species predominated by *V. rotundifolia* and only commercially cultivated in the southeastern United States. *V. rotundifolia* is known by its multiple resistance to almost all grape diseases and insects found on the *Euvitis* species, while the latter possesses good fruit characteristics that do not exist in muscadines. Attempts to produce *rotundifolia*-*vinifera* hybrids to combine good fruit quality and disease resistance of both into F<sub>1</sub> hybrids have been made by grape breeders for many years. Limited success was reported when the *V. vinifera* was used as seed parents. This research extended the interspecific crosses beyond *V. vinifera* into other *Euvitis* species. Among the *Euvitis* species, *A. aestivalis*, *V. cinerea*, *V. champinii*, *V. labrusca*, *V. monticola*, *V. nesbittiana*, *V. riparia*, *V. rupestris*, *V. thunbergii*, *V. quinquangularis*, all with pistillate flowers, were used as female parents pollinated with *V. rotundifolia* pollen. Eight out of the 10 cross combinations except *V. cinerea* and *V. thunbergii* set fruits. However, most of the *Euvitis*-*rotundifolia* crosses had extremely low fruits set (<1% of pollinated flowers). The only exception was *V. labrusca* cv. Woodruff, which had very high percentage of fruit set (70%). Interestingly, the fruits of *V. labrusca* cv. Woodruff x *rotundifolia* were parthenocarpic that had only half size of regular fruits set from open pollination with pollen sources from other *Euvitis* species. In the reciprocal crosses, three pistillate *V. rotundifolia* cultivars, 'Fry', 'Higgins', 'Jumbo', were used as female pollinated by pollen from *Euvitis* species. Limited fruit sets were found from the crosses of *V. rotundifolia* x *V. shuttleworthii*, *V. cordifolia*, *V. rupestris*, *V. piasezkii*, *V. quinquangularis*. Results from this study indicated that hybridization between *Euvitis* and *muscadinia* species is indeed very difficult but

it is possible, and some *Euvitis* species are cross more compatible with *V. rotundifolia* than the others.

605

### *Agrobacterium*-mediated Cranberry (*Vaccinium macrocarpon*) Transformation

Luping Qu\*, James Polashock, and Nicholi Vorsa; Blueberry and Cranberry Research Center, Rutgers University, Chatsworth, NJ 08019

Putative transgenic cranberry plants have been achieved via *Agrobacterium*-mediated transformation. Leaf explants were transformed with a supervirulent *Agrobacterium tumefaciens* strain EHA 105, harboring the binary vector P35SGUSint and *nptII* selectable marker genes. Inoculation of precultured explants (≈10 days on regeneration medium) coupled with sonication improved transformation efficiency significantly. Adventitious shoots were directly regenerated from explants. Putative transformed shoots were identified by being kanamycin-resistant and GUS-positive. Stable GUS gene expression (turning blue) could be detected within 1 h of incubation at 37 °C. Confirmation of transformation by molecular analysis is in progress. Eight putative transgenic cranberry plants were obtained. All appeared morphologically normal. This appears to be the first success in achieving cranberry transformed plants by *Agrobacterium*-mediated method. Optimizing the transformation system is ongoing.

606

### In Vitro Propagation of Some Strawberry Cultivars in Response to Kind and Concentration of Some Cytokinin Compounds

M.H. Aboul-Nasr\*, S.Z. Elagamy, and A.M. Kassim; Dept. of Horticulture, Faculty of Agriculture, Assiut Univ., Assiut, Egypt

Three strawberry cultivars were used in this study. Runners from the three cultivars were grown on Murashige and Skoog medium supplemented with benzylaminopurine or kinetin at four concentrations (2, 1, 0.5, and 0.25 mg·L<sup>-1</sup> in addition to the control treatment). The use of cytokinin, regardless of type and concentration, promoted the explant proliferation, shoot height, number of leaves, and plantlet fresh weight. Callus formation was enhanced by BA application, especially with 'Pajaro'. However, 'Chandler' did not form at all using cytokinin. Produced plantlets had lower nutrient constituents (N, P, K, Ca, and Na) when grown on media containing cytokinin compared to the control. Based on these results, cytokinin is recommended to get more shoots per explant. Furthermore, using the lowest concentration (0.25 mg·L<sup>-1</sup>) will produce height proliferation, greater shoot length, and more leaves.

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## 137 ORAL SESSION 26 (Abstr. 607–614)

### Vegetable Crops: Crop Physiology

Wednesday, 26 July, 10:00 a.m.–12:00 noon

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607

### Modulation of Heat Shock Proteins in Potato Leaves by Rhizospheric Calcium: Mitigation of Heat Stress Effect

Sookhee Park\* and Jiwan P. Patta; Department of Horticulture, University of Wisconsin, Madison, WI 53706

High temperature effects potato production by reducing overall growth and partitioning of photosynthate to tubers. Recent studies from our laboratory demonstrated that these effects can be reduced by increasing rhizospheric calcium. This present study was conducted to determine if this mitigation of heat stress effect on potato is due to modulation of heat shock protein by calcium during stress. An inert medium and nutrient delivery system capable of maintaining precise rhizospheric calcium levels were used. Biomass was measured and protein samples were collected from potato leaves. Using electroblotting, heat shock proteins were detected by antibodies to Hsp21 and Hsp70 (obtained from Dr. Elizabeth Vierling). Injury by prolonged heat stress was mitigated at calcium concentration >5 ppm. The calcium concentration of leaf and stem tissues were twice as high in 25 ppm calcium-treated plant compared to 1 ppm calcium-treated plants. Total foliage fresh weight was 33% higher and dry weight 20% higher in plants supplied with 25 ppm of calcium than supplied with 1 ppm of calcium. HSP21 was expressed only at high temperature and at greater concentrations in 25 ppm

calcium treatment. HSP70 was expressed in both control, 20 °C/15 °C (day/night) and heat-stressed tissue, 35 °C/25 °C (day/night) under various calcium treatments (1 to 25 ppm). Also, there were some differences in HSPs expression patterns between young and mature leaves. Young tissue responded immediately to the heat stress and started to express HSP21 within 1 day. Mature tissue started to express HSP21 after 2 days. HSP21 of young tissue disappeared sooner than mature tissue when heat stress-treated plants were returned to normal conditions. These results support our earlier studies indicating that an increase in rhizospheric calcium mitigate heat stress effects on the potato plant. Furthermore these results suggest that this mitigation may be due to modulation of HSP21 by rhizospheric calcium during heat stress.

## 608 Super-elevated CO<sub>2</sub> Concentrations Reduce Growth of Radish and Lettuce

R.M. Wheeler<sup>1</sup>, C.L. Mackowiak<sup>2</sup>, N.C. Yorio<sup>3</sup>, L.M. Ruffe<sup>3</sup>, and G.W. Stutte<sup>3</sup>;  
<sup>1</sup>NASA Biomedical Office and <sup>2</sup>Dyanamc Corp., Kennedy Space Center, FL 32899;  
<sup>2</sup>Dept. Plants, Soils, Biometeorology, Utah State University, Logan, UT 84322

Radish (*Raphanus sativus* cv. Giant White Globe) and lettuce (*Lactuca sativa* cv. Waldmann's Green) plants were grown for 25 days in growth chambers at 23 °C,  $\approx 300 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  PPF, and 18/6 photoperiod, and four CO<sub>2</sub> concentrations: 400, 1000, 5000, and 10,000  $\mu\text{mol}\cdot\text{mol}^{-1}$ . Average total dry mass (g/plant) at the 400, 1000, 5000 and 10,000  $\mu\text{mol}\cdot\text{mol}^{-1}$  treatments were 6.4, 7.2, 5.9, and 5.0 for radish and 4.2, 6.2, 6.6, and 4.0 for lettuce. Each species showed an expected increase in yield as CO<sub>2</sub> was elevated from 400 to 1000  $\mu\text{mol}\cdot\text{mol}^{-1}$ , but super-elevating the CO<sub>2</sub> to 10,000  $\mu\text{mol}\cdot\text{mol}^{-1}$  resulted in suboptimal growth. In addition, many radish leaves showed necrotic lesions at 10,000  $\mu\text{mol}\cdot\text{mol}^{-1}$  by 17 days and at 5000  $\mu\text{mol}\cdot\text{mol}^{-1}$  by 20 days. These results are consistent with preliminary tests in which radish cvs. Cherry Belle, Giant White Globe, and Early Scarlet Globe were grown for 16 days at 400, 1000, 5000, and 10,000  $\mu\text{mol}\cdot\text{mol}^{-1}$ . In that study, 'Giant White Globe' produced the greatest total dry mass at 1000 (3.0 g/plant) and 5000  $\mu\text{mol}\cdot\text{mol}^{-1}$  (3.0 g/plant), and the least at 10,000  $\mu\text{mol}\cdot\text{mol}^{-1}$  (2.2 g/plant). 'Early Scarlet Globe' followed a similar trend, but 'Cherry Belle' showed little difference among CO<sub>2</sub> treatments. Results suggest that super-elevated CO<sub>2</sub> can depress growth of some species, and that sensitivities can vary among genotypes.

## 609 Effects of CO<sub>2</sub> Concentration and Photoperiod on Growth of Lettuce under High Humidity Conditions

Yoshiaki Kitaya\*, Tsutomu Moriya, and Makoto Kiyota; College of Agriculture, Osaka Prefecture University, Gakuen-cho 1-1, Sakai, Osaka, 599-8531, Japan

Supplemental lighting and CO<sub>2</sub> enrichment have been employed to promote plant growth in commercial plant production in greenhouses. In a semi-closed plant production system with a large number of plants at a high density, the relative humidity in the air around growing plants could be in excess of 80%. This research was initiated to determine the effects of CO<sub>2</sub> concentration and photoperiod on the growth of plants under relatively high humidity conditions. In the experiment, lettuce plants were grown for 13 days under eight combinations of two CO<sub>2</sub> levels (CO<sub>2</sub>, 0.38 and 0.76  $\text{mmol}\cdot\text{mol}^{-1}$ ), two photoperiods (PP, 16 and 24 h/day), and two relative humidity levels (RH, 80% and 90%) in growth chambers. The air temperature was 25 °C. Plants were illuminated with fluorescent lamps at a photosynthetic photon flux of 0.23  $\text{mmol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ . The dry mass of lettuce shoots (leaves and stems) grown in 0.76  $\text{mmol}\cdot\text{mol}^{-1}$  CO<sub>2</sub>, 24 h/day PP, and 80% to 90% RH was greatest in all treatments and was five times the least value obtained in 0.38  $\text{mmol}\cdot\text{mol}^{-1}$  CO<sub>2</sub>, 16 h/day PP and 90% RH. The dry mass of lettuce shoots decreased to 40% as RH increased from 80% to 90% under 0.38–0.76  $\text{mmol}\cdot\text{mol}^{-1}$  CO<sub>2</sub> and 16 h/day PP. Growth suppression by excess humidity was less significant in longer PP and higher CO<sub>2</sub>. Supplemental lighting and CO<sub>2</sub> enrichment would be more effective for promoting growth of plants grown under higher humidity conditions.

## 610 Growth and Cutting Production Rates of Sweetpotato as Affected by CO<sub>2</sub> Concentration

Chieri Kubota\*, Haruna Maruko, and Toyoki Kozai; Dept. of Bioproduction Science, Faculty of Horticulture, Chiba Univ., Matsudo, Chiba 271-8510, Japan

For vegetative propagation of sweetpotato, single or multi-node leafy cuttings are used as propagules. A quantitative understanding of leaf development is

important for predicting the number of propagules produced after a given production period under various environmental conditions. For plant production in a relatively closed structure, controlling CO<sub>2</sub> concentration is necessary, but effects of CO<sub>2</sub> concentration on cutting production rates of sweetpotato are not well-investigated. Single-node cuttings each with a fully expanded leaf (the initial leaf blade length was 66 mm) were grown under one of three levels of CO<sub>2</sub> concentration (400, 800, and 1200  $\mu\text{mol}\cdot\text{mol}^{-1}$ ), 250  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  PPF, 16 h/day photoperiod, and 29 °C air temperature. The plant dry weight increased faster in the higher CO<sub>2</sub> concentrations. Changes in the number of harvestable cuttings during the production period was defined by changes in the number of leaves reaching a leaf blade length (LBL) longer than a given standard length (L<sub>s</sub>). The number of harvestable cuttings increased almost linearly with time after the LBL of the first leaf reached the L<sub>s</sub>, regardless of CO<sub>2</sub> concentration. The effect of CO<sub>2</sub> concentration on cutting production rate (number of harvestable cuttings per day) was varied with different L<sub>s</sub>. For example, at L<sub>s</sub> = 20, 30, and 40 mm, the cutting production rate increased slightly at higher CO<sub>2</sub> concentrations, while at L<sub>s</sub> = 60 mm, it decreased significantly at higher CO<sub>2</sub> concentrations. This indicates that, under the present experimental conditions, increasing CO<sub>2</sub> concentration increased the number of small leaves that might not be usable as cuttings (propagules). Environmental control is necessary in vegetative propagation to increase the number of propagules and the biomass usable as propagules, thereby minimizing energy and resources needed for the propagule/transplant production process.

## 611 High Temperature Acclimation and Catalase Stability in Pepper Leaves

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Activated forms of oxygen, including hydrogen peroxide, have been implicated in plant responses to stress. Environmental stresses may increase prooxidants, impair defense systems, or both. Stress acclimation may involve changes in capacity or stability of activated oxygen defenses. Catalases and peroxidases are the primary enzymatic detoxifiers of hydrogen peroxide in most plant tissues. Pepper leaf disks treated with hydrogen peroxide solutions from 0 to 100 mM showed increased electrolyte leakage and ethylene and methanol evolution with increasing concentration, but changes were slight compared to freeze-killed tissues. Data suggested that pepper leaves had considerable capacity to detoxify hydrogen peroxide. Cellular damage in heat-stressed tissues occurred over a similar temperature range that catalase activity declined. Leaf disks exposed to 24 to 59 °C for 15 min exhibited a sigmoidal electrolyte leakage response curve with an inflection at 51.5 °C. A similar plot of catalase activity vs. temperature exhibited an inflection point at 53.1 °C. Thermotolerance of plants exposed to the acclimating regime of 38 °C day/30 °C night increased from 50.7 to 53.9 °C based on electrolyte leakage. Catalase activity also showed an adaptive response with the inflection point increasing from 52.6 to 56.8 °C. It appears that catalase activity remains stable to a higher temperature in acclimated leaves, with similar activity in nonstressed control and acclimated plants.

## 612 The Relationship of Pollen Development and Release to Fruit and Seed Production in Tomato Cultivars Exposed to Heat Stress at Varying Humidity Levels

M.M. Peel\*, C. Clemen<sup>2</sup>, and S. Sato<sup>3</sup>; Depts. of <sup>1</sup>Horticultural Science and <sup>3</sup>Crop Science, North Carolina State University, Raleigh, NC 27695-7609; <sup>2</sup>Universite de Reims Champagne Ardenne, UFR Sciences, Biologie et Physiologie Vegetales, BP 1039, 51687 Reims Cedex 2, France

Starting 2 weeks before anthesis of the first flower, tomato cultivars (*Lycopersicon esculentum* Mill.) differing in heat tolerance were exposed to mild heat stress (31/24 vs. 28/22 °C) at three levels of relative humidity (30%, 60%, and 90%) in controlled environment chambers at the Duke Univ. Phytotron. Pollen development in the anthers was followed cytologically, pollen release was measured at anthesis, and seed production and fruit weight were measured as fruit matured. Fruit and seed development were best at 60%RH and 28/22 °C and worst at 90% RH and 31/24. Seed development was poor at 31/24 °C at all humidity levels. It was also poor at 28/22 in the 90% RH treatment. Low relative humidity had a greater negative effect on fruit and seed production and on cytological development in plants grown at high temperature. Pollen release was also reduced at 90% RH, with virtually no pollen released at 31/24 °C. Cytological examinations revealed developmental anomalies in pollen in some, but not all

cultivars at 90% and 30% RH. Plant height was also affected by the treatments, with much taller plants in the high-temperature, high-humidity treatments.

613

### Mitigation of Ethephon Injury to Tomato Plants by a Natural Lipid Lysophosphatidylethanolamine (LPE): Influence on the Activity of Phospholipase D (PLD)

Mustafa Ozgen\*, Jiwan P. Palta, and Stephen B. Ryu. Department of Horticulture, University of Wisconsin, Madison, WI 53706

Ethephon [2-(chloroethyl) phosphonic acid] is used widely to maximize the yield of ripe tomato fruits. However, ethephon causes rapid and extensive defoliation, overripening, and promotes sunscald damage to the fruit. Recent studies from our laboratory have provided evidence that lysophosphatidylethanolamine (LPE) can reduce leaf senescence. We investigated the potential use of LPE to reduce damaging effect of ethephon on tomato foliage and influence on the activity of phospholipase D (PLD). Disruption of membrane integrity has been suggested as a primary cause of senescence in plants. PLD is known to be a key enzyme, which initiates the selective degradation of membrane phospholipids in senescing tissues. Two-month-old tomato plants ('Mountain Spring') grown in greenhouse condition were sprayed with water, 200 ppm LPE, and 1000 ppm ethephon. In addition, LPE spray prior to ethephon or mixture with ethephon were also tested. Leaves were sampled after 0, 2, 5, 24, 72, and 168 h of spray application, for PLD activity measurements. Spray of LPE prior to ethephon spray or inclusion of LPE in the ethephon spray reduced foliar injury by ethephon. Activity of soluble PLD was increased dramatically in leaves sprayed with ethephon initially and then dropped by 7 days. We also found that LPE-treated leaves had lower PLD activity than the ethephon-treated leaves. Plants treated with LPE-ethephon mixture also showed significantly lower PLD activity. These results suggest that LPE treatments mitigate ethephon injury to tomato plants. Furthermore, it appears that this mitigation involves modulation of the activity of PLD.

614

### Ethephon Induced Differential Ripening and Enzyme Activity Response in Two Tabasco Lines

Carl E. Motsenbocker\* and Ramon A. Arancibia. Department of Horticulture, LSU AgCenter, Baton Rouge, LA 70803

Two tabasco pepper (*Capsicum frutescens* L.) lines were previously identified that differ in fruit detachment characteristics. Ethephon treatment (1000 µl/L) to intact tabasco fruit 29 days after anthesis (green-mature) enhanced ripening as indicated by fruit coloration in both lines. 'McIlhenny Select' fruit, which normally separate readily at the red-mature stage, however, had a quicker ripening response compared to 'Hard Pick' fruit. Ethephon increased cellulase activity in the fruit tissue of both tabasco lines compared to the untreated control, and there was a trend of higher cellulase activity in 'McIlhenny Select' compared to 'Hard Pick'. Differences in ripening and enzyme activity in response to ethylene generators indicate that the two tabasco lines are suitable material to investigate the physiological processes involved in pepper fruit ripening.

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## 138 ORAL SESSION 27 (Abstr. 615–621) Floriculture/Foliage: Crop Production Wednesday, 26 July, 10:00–11:30 a.m

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615

### Colored Shade Nets can Manipulate the Vegetative Growth and Flowering Behavior of Ornamental Plants

M. Oren-Shamir<sup>1</sup>, E.E. Gussakovsky<sup>1</sup>, E. Shpiegel<sup>2</sup>, E. Matan<sup>3</sup>, I. Dory<sup>3</sup>, and Y. Shahak<sup>1</sup>. <sup>1</sup>Inst. of Horticulture, A.R.O. The Volcani Center, Bet-Dagan 50250, Israel; <sup>2</sup>Dept. of Floriculture, Extension Service, Ministry of Agriculture, Israel; <sup>3</sup>Southern R&D, Bsoar Experimental Station, Israel

Many green-decorative branches ("Greens") and cut flowers are commercially grown under shade nets, for both the reduction of the natural intercepted sunlight as well as physical protection. The most commonly used are black nets, which do not affect the visible light spectrum. In the work presented here we have studied the effects of shade nets of varying optical properties on the vegetative and flowering responses of ornamental plants, searching for nets that will spe-

cifically induce a desired behavior, thus gaining benefits in addition to the mere shading. Nets of different transmittance spectra, light scattering, reflectance and thermal properties are being studied for their effect on the vegetative growth of several Greens: *Pittosporum variegatum*, *Ruscus hypoglossum*, and Leather-leaf fern. The knitting density of all nets has been adjusted to have the same percent shading in the PAR (photosynthetically active radiation) range of the spectrum for all nets investigated. Experiments were carried out in commercial plots. Data were collected for microclimate, physiological and horticultural parameters. The main results obtained so far: i) pronounced stimulation of the vegetative growth under the Red net; ii) dwarfing by the Blue net; iii) the Grey net markedly enhanced branching, yielding "bushy" plants with short side branches; iv) the reflective, thermal net (Aluminet<sup>®</sup>) enhanced side, long branching (in *Pittosporum*). Recently we have applied a similar approach to cut flowers such as *Lupinus luteus*, *Lisianthus eustoma*, and *Dubium ornitogalum*, and obtained dramatic effects of some of the nets on both the vegetative development and flowering behavior. The results to be presented, suggest that sophistication of the use of shade nets can lead to better agricultural performance.

616

### Effect of Temperature on Flower Size of *Campanula carpatica* 'Blue Clips' and 'Birch Hybrid'

Genhua Niu\*, Royal D. Heins, Arthur C. Cameron, and William H. Carlson. Department of Horticulture, Michigan State University, East Lansing, MI 48824

Flower size generally decreases as temperature increases. The objective of this research was to investigate during development when flowers of *Campanula carpatica* Jacq. 'Blue Clips' and 'Birch Hybrid' are sensitive to temperature by conducting two temperature-transfer experiments. In the first experiment, plants were grown initially at 20 °C and then transferred at visible bud to 14, 17, 20, 23, or 26 °C until flower. In the second experiment, plants were transferred from 14 to 26 °C or from 26 to 14 °C at 1, 3, or 5 weeks ('Blue Clips') or at 1, 2, or 3 weeks ('Birch Hybrid') after flower induction. Temperature before visible bud had little effect on final flower size for both species. For example, flower diameter of 'Blue Clips' was similar among plants grown at constant 14 °C or grown at 20 °C initially and then transferred at visible bud to 14 or 17 °C. Similarly, flower diameter of plants grown at constant 26 °C was similar to those grown at 20 °C initially and then transferred at visible bud to 26 °C. Flower diameter in these species is correlated with the temperature after VB in the 14 to 26 °C and decreases linearly as the temperature after VB increases.

617

### Day and Night Temperatures, Daily Light Integral, and CO<sub>2</sub> Enrichment Affect Growth and Flower Development of *Campanula carpatica* 'Blue Clips'

Genhua Niu\*, Royal D. Heins, Arthur C. Cameron, and William H. Carlson. Department of Horticulture, Michigan State University, East Lansing, MI 48824

*Campanula carpatica* Jacq. 'Blue Clips' plants were grown in a greenhouse under ambient (400 µmol·mol<sup>-1</sup>) and enriched (600 µmol·mol<sup>-1</sup>) CO<sub>2</sub> concentrations, three daily light integrals (DLI): 4.2, 10.8, and 15.8 mol/m per day, and nine combinations of day and night temperatures created by moving plants every 12 h among three temperatures (15, 20, and 25 °C). Time to flower decreased as plant average daily temperature (ADT) increased. Flower diameter decreased linearly as ADT increased in the 15 to 25 °C range and was not related to the difference between day and night temperatures (DIF). Increasing DLI from 4.2 to 10.8 mol/m per day also increased flower diameter by 3 to 4 mm regardless of temperature, but no difference was observed between 10.8 and 15.8 mol/m per day. Carbon dioxide enrichment increased flower diameter by 2 to 3 mm. Number of flower buds and dry mass at high and medium DLI decreased as plant ADT increased. Plant height increased as DIF increased from 6 to 12 °C. Number of flower buds and dry mass were correlated closely with the ratio of DLI to daily thermal time using a base temperature of 0 °C.

618

### Effect of Preplant Hot-water and Fungicide Treatments on Tuber Development of Caladiums

Gary J. Wilfret\*. Gulf Coast Research and Education Center, University of Florida, Bradenton, FL 34203

Intact tubers of *Caladium* cv. Florida Elise were soaked for 30 min in water at 24 or 50 °C in 1998 and manually cut into cubes with 2-cm sides. Propagules were planted on 15-cm centers in raised sand beds covered with white plastic. Tubers were harvested in 6 months, air-dried, cleaned, weighed, and graded.

Yield of No. 2 tubers (>1.9 <3.8 cm diam) was increased 31%, total tuber weight was 13% greater, and the production index was 13% larger due to hot-water treatment. No differences were determined for other tuber sizes. Tubers harvested from both treatments were soaked for 30 min in 1999 in water at 24 or 50 °C or in water at 24 or 50 °C that contained the fungicide Systec 85WDG [thiophanate methyl(dimethyl{(1,2-phenylene)-bis(iminocarbonothioyl)})bis(carbamate)] at 33.6 g/20 L. Tubers were cut and planted as in 1998 and harvested in 2000. Tuber yields and production indices were greater in all hot-water treatments, but were not increased by fungicides alone. Yields from tubers that were not hot-water treated in 1998 but were soaked in hot water in 1999 were similar to those tubers that were hot-water-treated in both years. Fungicides did not have an additive effect when hot-water was used.

619

### Cold Pretreatment, Planting Depth, and Shade Affect Cut Stem Quality and Perennialization of Field-grown Dutch Bulbs

Todd J. Cavins and John M. Dole\*: Dept. of Horticulture and Landscape Architecture, Oklahoma State Univ., Stillwater, OK 74078-6027

*Hyacinthoides hispanica* (Mill.) Roth., *Hyacinthus orientalis* L. 'Gypsy Queen', *Narcissus pseudonarcissus* L. 'Music Hall', *N. pseudonarcissus* 'Tahiti', *Tulipa gesneriana* L. 'Couleur Cardinal', and *T. gesneriana* 'White Emperor' bulbs were given 0 or 6 weeks of preplant 5 °C cold treatment and planted 15, 30, or 45 cm deep into raised ground beds under 0%, 30%, or 60% shade. Plant growth was monitored for 2 years after planting. Preplant 5 °C cold pretreatment reduced percentage of *Tulipa* 'White Emperor' bulbs that flowered but did not affect the percentage of bulbs that flowered for the other species. Cold pretreatment also delayed anthesis in one or both years for all cultivars except *Hyacinthoides hispanica*. The greatest percentage of bulbs flowered when planted 15 cm deep. The 45-cm planting depth reduced bulb flowering percentage or eliminated plant emergence. Increasing planting depth increased days to anthesis for all cultivars in both years. Increasing shade increased stem lengths in year 2 for all cultivars except *Hyacinthoides hispanica*, but did not influence percentage of bulbs flowering for any cultivars. For all cultivars perennialization was low regardless of treatment as less than 30% of bulbs survived to the 2nd year.

620

### Enhancing Germination of Purple Coneflower (*Echinacea angustifolia*) Using Stratification, Salt Priming, and Biostimulants

Gladis M. Zinati\*, Herbert H. Bryan, and Yuncong Li: University of Florida, Tropical Research and Education Center, 18905 S.W. 280 St., Homestead, FL 33031

Using herbs for medicinal purposes, ornamentals, and landscape plantings has increased significantly. Propagating from seeds is considered the most-efficient method of producing medicinal plants for commercial production. Among the herb seeds the purple coneflower (*Echinacea angustifolia*) was found difficult to germinate. Laboratory studies were conducted to: 1) determine optimum temperature from a temperature range 15 to 30 °C for seed germination; 2) determine effects of 5, 10, 20, and 30 days of stratification at 5 and 10 °C in darkness on germination; and 3) determine effects of priming in the dark for 1, 3, 6, and 9 days with 0.1 M KNO<sub>3</sub> and biostimulants at optimum temperature to enhance early emergence and final germination. Germination was enhanced from 45% in untreated seeds to 81% in seeds treated with either 50 ppm GA<sub>4/7</sub> or 100 ppm ethephon at 24 °C. Final germination was 81% under daylight conditions when seeds were stratified in dark at 10 °C for 30 days over nonstratified seeds (13%). Priming seeds in 0.1 M KNO<sub>3</sub> for 3 days significantly enhanced early germination to 70% with 100 and 150 ppm ethephon and final percent germination of 88% with either 100 ppm ethephon or 150 ppm GA<sub>4/7</sub>, while untreated control seeds resulted in 31% for same period of priming.

621

### Optimizing Marigold (*Tagetes erecta* L.) Petal and Pigment Yield

Theresa Bosma\*, John Dole, and Niels Maness: Oklahoma State Univ., Dept. of Horticulture and Landscape Architecture, Stillwater, OK 74078-6027

Marigold flower pigments can be extracted and used as a natural source of food colorants in the poultry and dairy industry. These pigments impart an orange color to egg yolks and a yellowish color to dairy products. We examined four African marigold cultivars for their ability to be commercially grown and

harvested mechanically. 'E-1236' yielded the highest quantity of lutein (22 kg/ha), a carotenoid pigment, using a spectrophotometer for quantification. 'E-1236' and 'A-975' were the earliest flowering cultivars, 11 June 1998 for transplants and 9 July 1998 for direct-seeded, at 8 weeks after sowing regardless of field establishment method. 'E-1236' produced the greatest number of flowers in a production season, both as transplants (68 flowers/plant) and direct-seeded (57 flowers/plant) at 363,290 plants/ha. Transplants resulted in two more harvests in a single season than direct-seeded plants. Subsequently, more flowers and petal material were produced for pigment extraction than with direct-seeded plants. A one-time application of ammonium nitrate (28.02 kg/ha) at mid-season did not significantly effect flower number, flower weight, or pigment yield. Experiment was repeated in 1999 with four cultivars, two field establishment methods, seven harvest dates, and five nitrogen applications.

## 139 ORAL SESSION 28 (Abstr. 622–628)

### Small Fruit/Viticulture: Crop Production

Wednesday, 26 July, 10:00–11:45 a.m.

622

### Initiation of Flowering, Runner Formation, and Carbohydrate Distribution in Strawberry (*Fragaria x ananassa* Duch.)

#### Mother and Daughter Plants Grown at Different Temperatures

D. Kirschbaum, D.J. Cantliffe\*, C.K. Chandler, and R.L. Darnell: IFAS, Univ. of Florida, Horticultural Sciences Dept., Gainesville, FL 32611-0690, USA

The present research was undertaken to examine carbohydrate composition and distribution patterns and induction of flowering and runner formation in attached and detached strawberry plants grown under varying temperature conditions. There was an interaction between attached mother and daughter plants. Daughter plants affected flowering in mother plants, and mother plants influenced vegetative growth in daughter plants. Attachment and high temperature decreased root soluble carbohydrate concentration and promoted runner formation in both mother and daughter attached plants, suggesting that changes in carbohydrate concentration in the roots may be correlated with changes in vegetative growth. According to the results of this research, high temperatures are likely to enhance vegetative growth, whereas lower temperatures are likely to enhance the floral response. Differential temperature regimes applied to the mother/daughter plant experimental system could be an alternative to photoperiod treatments as a tool to study the correlation between environmental conditions and changes in vegetative and reproductive growth in strawberry.

623

### Lowbush Blueberry Response to Phosphorus Fertilizers with Different P : N Ratios

John M. Smagala\*, Walter Litten, and Scott Dunham: Horticulture Program, Biosystems Science and Engineering Dept., 416 Deering Hall, Univ. of Maine, Orono, ME 04469-5722

In three commercial fields with a history of low leaf P concentrations, triple super phosphate (TSP) (1 P : 0 N), monoammonium phosphate (MAP) (2.1 P : 1 N), and diammonium phosphate (DAP) (1.11 P : 1 N) with P at 67.2 kg·ha<sup>-1</sup> were compared to a control in a randomized complete-block design with 12 blocks. In 1995, all fertilizer treatments were comparable in raising soil P concentrations, but MAP and DAP resulted in higher P leaf concentrations compared to the control. DAP was more effective than MAP in raising N leaf concentrations. Leaf concentrations of Mg, B, and Cu were lowered by MAP and DAP but not TSP. Stem density, stem length, flower buds per stem, flower bud density, and yield were raised by DAP. The same treatments were applied in May 1997 and in May 1999 to the same plots in the same fields. In 1997, by the time of tip dieback in the prune year of that cycle, foliar concentration of P and N averaged higher than in the previous cycle, but still were not up to the standard for N. Fruit yield for the second cycle averaged substantially higher for the controls and for all three treatments, most dramatically for the DAP. In 1999, with only two fields available, response to treatments depended on soil N availability. At the field where leaf N was lower in control plots, MAP and DAP were more effective than TSP in raising leaf P.



### Nitrate and Iron Reductase Activities in *Vaccinium* Species

*Umpika Poonnachit and Rebecca L. Darnell\**; Horticultural Sciences Dept., University of Florida, Gainesville, FL 32611

*Vaccinium corymbosum*, one of the cultivated blueberry species, is not well-adapted to mineral soils, which are generally marked by high pH, the predominance of  $\text{NO}_3\text{-N}$  over  $\text{NH}_4\text{-N}$ , and limited iron availability. A wild species, *V. arboreum*, grows naturally on mineral soils, and thus may be better adapted than *V. corymbosum*. This adaptation may be related to the ability of *V. arboreum* to assimilate  $\text{NO}_3$  and/or iron more efficiently than *V. corymbosum*. Both species were grown in a hydroponic solution containing 5.0 mM N as  $(\text{NH}_4)_2\text{SO}_4$  or  $\text{NaNO}_3$ , and buffered to pH 5.5. Nitrate reductase (NR) and iron reductase (FeR) activities were measured. NR activity was higher in *V. arboreum* compared with *V. corymbosum* when grown with  $\text{NO}_3\text{-N}$ , while no difference between species was observed when grown under  $\text{NH}_4\text{-N}$ . Activity of FeR was higher in *V. arboreum* compared with *V. corymbosum*, and higher under  $\text{NO}_3\text{-N}$  compared with  $\text{NH}_4\text{-N}$ . After 5 months in hydroponics, Fe was removed from one-half of the solutions. The activity of NRA in both species was higher under Fe-sufficient compared with Fe-limited conditions, but in both cases, activity was higher in *V. arboreum* compared with *V. corymbosum*. FeR activity continued to be higher in *V. arboreum* compared with *V. corymbosum*, and under  $\text{NO}_3$  compared with  $\text{NH}_4\text{-N}$ . Activity decreased in both species under limited Fe conditions, and there were no interactions between species and Fe. These data indicate that *V. arboreum* possesses higher NR and FeR activities than *V. corymbosum*, under both Fe-sufficient and Fe-limited conditions. This may play a role in the better adaptability of *V. arboreum* to mineral soil conditions.

## 625

### Early Fall Defoliation of Southern Highbush Blueberry Inhibits Flower Bud Initiation and Retards Flower Bud Development

*Jeffrey G. Williamson\* and E.P. Miller*; Horticultural Sciences Dept., University of Florida, Gainesville, FL 32611-0690

In 1998, representative canes of mature, field-grown, 'Misty' and 'Sharpblue' southern highbush blueberry were hand-defoliated on 4 Sept., 2 Oct., 6 Nov., 7 Dec., or not defoliated. The experiment was repeated in 1999. Randomized complete-block designs with 11 (1998) or 10 (1999) replications were used. The early defoliation treatments (4 Sept. and 2 Oct.) resulted in reduced flower bud number per unit length of cane for 'Misty', but not for 'Sharpblue', when compared with later defoliation treatments or controls. A similar response to early defoliation was found both years for both cultivars. The later defoliation treatments (6 Nov. and 7 Dec.) had no significant effect on flower bud number compared to controls. Early defoliation had a negative effect on flower bud development for both cultivars. Flower buds that developed on canes defoliated on 4 Sept. or on 2 Oct. had smaller diameters than flower buds on canes defoliated on 6 Nov., 7 Dec., or on non-defoliated canes. Fruit fresh weight per unit cane length was less for the September and October defoliation treatments than for the December defoliation treatment or controls. These results support the need for summer pruning and a effective summer spray program to control leaf spot diseases that often result in early fall defoliation of southern highbush blueberries grown in the southeastern United States.

## 626

### Field Assessment of Combined Bud Damage on Floricanes of Red Raspberry Caused by Cold Injury, Clay Colored Weevil, and Spur Blight Disease

*Chuhe Chen\*, Lynell Tanigoshi, Stephen F. Klauer, Geoff Menzies, and J. Scott Cameron*; Washington State University Research and Extension Unit, Vancouver, WA 98665

A field experiment was conducted in Lynden, Wash., to assess the combined bud damage to raspberry caused by cold injury, clay colored weevil (CCW) and spur blight disease last year. The CCW treatments included 3 and 6 weeks of continuous feedings and a minimal feeding in a nearby planting with no CCW infestation. Two other sets of field experiments evaluated cold injury to raspberry alone. Cold injury caused significant bud damage and moderate yield losses last winter. The large compensatory ability of raspberry makes yield loss due to cold injury alone insignificant in most years. Cold injury reduced berry yield mainly through a drop in lateral number/cane due to bud damage and cane die back. The combined damage of cold injury with infestations of CCW and spur blight, to the

buds and fruit yield were devastating, and 60% bud damage and 61% yield loss were recorded. The combined damage was well over the compensatory ability of raspberry, and resulted in not only lower lateral number/cane, but also lower fruit number/lateral and fruit weight. The bud damage by CCW in the spring left little time for the secondary laterals to initiate flowers. An integrated pest management system is highly recommended to avoid the cumulative damage to the buds and has special importance in areas, where cold injury occurs frequently. Bud damage counted as cold injury was higher in the control plots (18%) than in the weevil-infested plots (6% to 9%). This was likely due to undercount of some cold damaged buds in the infested plots, which also suffered CCW feeding. All plots had similar levels of spur blight bud infection numbering from low to mid-teens. Spur blight-infected buds are often capable of producing normal fruiting laterals.

## 627

### Harvester Adjustments Substantially Increase Fruit Yield and Quality for the Split Versus Conventional Trellis in Red Raspberry

*Stephen F. Klauer\*, Chuhe Chen, and J. Scott Cameron*; Washington State Univ. Research and Extension Unit, Vancouver, WA 98665

In 1999, yield of the split (ST) vs. conventional trellis (CT) was again compared in "Meeker" red raspberry. Field-testing was repeated at four sites in north (Lynden) and southwest (Woodland, Ridgefield, WSUV REU) Wash. A variety of widths, crossarm styles, and machine harvesters were tested in fields with varied cultural practices. Topped and tied-over canes were compared at two locations. In previous years, estimated yield potentials have been 20% to 60% greater for ST, but actual yields have only been 10% to 13% greater because of harvester damage to laterals and premature pick of green fruit. This year, Littau Harvester suggested minor machine adjustments that addressed these problems, resulting in a 19.4% yield increase for a 51-cm ST (Lynden). Lateral damage was minimized by spreading the picking heads to begin harvest, and then moving them closer after every three harvests. Excessive green fruit was controlled by reducing beater rod speed. A rough cost/benefit analysis indicates that there would be substantial economic gain (15% more \$/acre in this case, assuming \$0.50/lb fruit) for ST vs CT at this level of yield increase. There was no difference in harvest efficiency between treatments at WSUV. More fruit was lost to drop in the row center for ST in Lynden. Topped canes in CT and ST had reduced yields of 11 and 19% respectively compared to their tied-over counterparts. Topped ST canes had 11% greater yield than topped CT canes. ST canopies were larger, and had more leaves than CT. No differences were seen on a leaf-area basis between treatments for leaf:  $\text{CO}_2$  assimilation, fluorescence, and chlorophyll or in primocane leaf total nitrogen. Increased ST yields were recorded for a 2nd year at two locations, which supports yield sustainability for ST.

## 628

### Effect of Air Temperature on Growth Regulators in the Induction of Cold Hardiness in Blueberry

*Girish K. Panicker\*<sup>1</sup>, Frank B. Matta<sup>2</sup>, and Patrick D. Gerard<sup>2</sup>*; <sup>1</sup>Alcorn State Univ., Lorman, MS 39096; <sup>2</sup>Mississippi State Univ., Mississippi State, MS 39762

Air temperature on crop productivity is a complex topic in environmental physiology. Blueberry growers in the Southeastern United States experience major crop losses due to late spring frosts. A 2-year study was conducted on 'Tifblue' rabbiteye blueberry flower flushes to determine the effect of abscisic acid (ABA) at 0, 20, 40, and 60  $\text{mg}\cdot\text{L}^{-1}$  and paclobutrazol at 0, 100, 200, and 300  $\text{mg}\cdot\text{L}^{-1}$  on cold hardiness of floral parts. Two types of flower flushes were identified in 'Tifblue': Critical freezing temperatures and the effectiveness of the treatments were determined by differential thermal analysis (DTA), electrolyte leakage (EL), oxidative browning and tetrazolium staining. Floral parts frozen to  $-40^\circ\text{C}$  produced only one exotherm, confirming that rabbiteye floral parts do not supercool. Both growth regulators were more effective in the induction of hardiness in floral parts at second flush than at first flush. Floral parts developed in April were more prone to freezing injury than the floral parts of March. Ovaries were the hardest, followed by calyx, stamen, style, and corolla. Air temperature had a profound influence on cold hardiness as influenced by ABA and paclobutrazol. The sequence of exotherms of DTA and the  $\text{LT}_{50}$  of the viability tests were air temperature-dependent.

**157 ORAL SESSION 29 (Abstr. 629–634)**  
**Floriculture/Foliage: Crop Physiology**  
**Wednesday, 26 July, 2:00–3:30 p.m**

629

**Influence of Plant Growth Regulator Chemicals, on the Growth and Development of *Angelonia angustifolia* 'Blue Pacific', *Asteriscus maritimus* 'Compact Gold Coin', and *Heliotropium aborescens* 'Fragrant Delight'**

Amy Lynn Bartel\* and Terri W. Starman, Department of Ornamental Horticulture and Landscape Design, University of Tennessee, Knoxville, TN 37901

*Angelonia angustifolia* 'Blue Pacific', *Asteriscus maritimus* 'Compact Gold Coin', and *Heliotropium aborescens* 'Fragrant Delight' are three vegetatively propagated species of annuals. The objective of this study was to find which plant growth regulator chemicals could be used to control height and produce compact, well-branched, flowering plants. The plants arrived as rooted plugs and were transplanted to 10-cm plastic containers. When the roots of the transplanted plugs reached the edge of their containers, 15 days after transplanting, the plant growth regulator chemicals were applied. Five different chemicals were used in spray applications at two rates measured in mg/L: ancymidol at 66 and 132; daminozide at 2500 and 5000; paclobutrazol at 20 and 40; ethephon at 500 and 1000; and uniconazole at 10 and 20. One drench application of uniconazole at 1 and 2 mg/L and one control (water spray) were also used. Total plant height, plant width, flower number, node number, stem length, internode length, and numbers of days to visible bud were recorded. Ancymidol at both rates caused stunting and flower distortion in *Asteriscus*; however, it was not effective on *Angelonia* or *Heliotropium*. Paclobutrazol and uniconazole sprays were ineffective in controlling height on all three species. Ethephon at both rates was effective in controlling height, and producing well-branched plants in all three species, yet it caused a delay in flowering. Uniconazole drench at both rates was also effective in controlling height but caused stunting. In general, daminozide at 5000 mg/L was most effective in controlling foliage height without a delay in flowering or decrease in flower size or number in all three species.

630

**Growth Regulators Affect the Morphology and Flowering of *Argyranthemum*, *Calibrachoa*, and *Orthosiphon***

Hope K. Onken\* and Terri W. Starman, University of Tennessee, Ornamental Horticulture and Landscape Design, Knoxville, TN, 37901

*Argyranthemum frutescens* 'Sugar Baby', *Calibrachoa* hybrid 'Million Bells Cherry Pink', and *Orthosiphon stamineus* 'Lavender' are three vegetatively propagated specialty annuals that are recent introductions into the floriculture industry. It is important to understand how the growth and development of these new crops is best controlled. Rooted cuttings of these three species were transplanted into 10-cm pots on 7 Oct. and the plant growth regulator treatments were applied on 19 Oct. 1999. Foliar spray treatments included ancymidol at 66 and 132, daminozide at 2500 and 5000, paclobutrazol at 20 and 40, ethephon at 500 and 1000, and uniconazole at 10 and 20 mg/L. Uniconazole medium drench treatment was applied at 1 and 2 mg/L. Control was a water foliar spray. At harvest, plant height, plant width, number of flowers, pedicel length, stem length, stem node number and internode length, and fresh and dry weights were measured. Uniconazole spray at 20 mg/L reduced plant height and width without affecting the fresh and dry weights of *Argyranthemum*. Flower number was increased and pedicel length was reduced. The overall plant height and width of *Calibrachoa* were not reduced with 20 mg/L uniconazole foliar spray, but plant form was improved by decreased internode elongation. Uniconazole foliar spray at 20 mg/L reduced *Orthosiphon* stem and internode length. Ethephon reduced plant height, plant width, and flower number of all species. Branching and days to flower were increased in *Orthosiphon*. In all species, daminozide and paclobutrazol were found to be ineffective, while ancymidol spray and uniconazole drench stunted and distorted growth.

631

**Photocontrol of Flowering and Stem Extension of the Intermediate-day Plant *Echinacea purpurea* Moench.**

Erik S. Runkle\*, Royal D. Heins, Arthur C. Cameron, and William H. Carlson, Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325 USA

Intermediate-day plants (IDP) flower most rapidly and completely under intermediate photoperiods (e.g., 12 to 14 h of light), but few species have been identified and their flowering responses are not well understood. A variety of experiments was conducted to determine how light controls flowering and stem extension of *Echinacea purpurea* 'Bravado' and 'Magnus'. Both cultivars flowered most completely (79%) and rapidly and at the youngest physiological age under intermediate photoperiods of 13 to 15 h. Few (14%) plants flowered under 10- or 24-h photoperiods, indicating *E. purpurea* is a qualitative IDP. Plants were also induced to flower when 15-h dark periods were interrupted with as few as 7.5 min of low-intensity lighting (night interruption, NI). Flowering was progressively earlier as the NI increased to 1 h, but was delayed when the NI was extended to 4 h. Stem length increased by 230% as the photoperiod or NI duration increased, until plants received a saturating duration (at 14 h or 1 h, respectively). At macroscopic visible bud, transferring plants from long days to short days reduced stem extension by up to 30%. Flowering was inhibited when the entire photoperiod was deficient in blue or red light and was promoted in a far-red deficient environment, suggesting that phytochrome and cryptochrome control flowering of *E. purpurea*. Because of our results, we propose the flowering behavior of IDP such as *E. purpurea* is composed of two mechanisms: a dark-dependent response in which flowering is promoted by a short night, and a light-dependent response in which flowering is inhibited by a long day.

632

**GA<sub>4/7</sub> and Light Level Affect Flowering and Plant Height of New Cultivars and Genetic Lines of *Aquilegia xhybrida* Sims**

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*Aquilegia* cultivars 'Songbird Bluebird', 'Songbird Robin', 'Dove Improved', 'Colorado Violet/White' and five cultivars from new experimental genetic lines ('Red and White', 'Rose and White #1', 'Rose and White #2', 'Scarlet and Yellow' and 'White') will flower without vernalization, but little is known of their response to light or plant growth regulators. Plants were started from seed on 5 Jan. 1999 and grown in either natural light or 33% shade, and treated with gibberellins (GA<sub>4/7</sub>) at the seven-leaf stage. Flowering time, number of flowers/plant, and plant height were evaluated through 31 May 1999. All five cultivars from the new genetic lines bloomed during the study. 'White', grown in shade and treated with GA<sub>4/7</sub>, bloomed 2 weeks earlier (115 days) than untreated plants grown in natural light (130 days). 'Songbird Robin', treated with GA<sub>4/7</sub>, bloomed in 146 days, and was the only other cultivar to bloom. Flower numbers were greater in natural light than in 33% shade. GA<sub>4/7</sub> increased flowering for four of five cultivars, in the new genetic lines, grown in natural light. In shade, GA<sub>4/7</sub> increased flowering for three of five cultivars. Height response to GA<sub>4/7</sub> was significant in both natural light and 33% shade. Four of the five cultivars in the new genetic lines were taller when treated. All five of these cultivars were taller when grown in natural light versus 33% shade. 'White' and both 'Rose and White' cultivars were consistently taller, bloomed earlier and were more floriferous when treated with GA<sub>4/7</sub>.

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**The Influence of Temperature, Irradiance, and Photoperiod on Crop Growth and Flowering of *Angelonia angustifolia***

Amanda M. Miller\*, James M. Garner, and Allan M. Armitage, Department of Horticulture, University of Georgia, Athens, GA 30602

Five cultivars of the Angel Mist series of *Angelonia angustifolia* L. were evaluated in the Univ. of Georgia New Crop Program to determine the influence of temperature, irradiance, and photoperiod on crop growth and flowering. When the temperature was increased from 15 to 30 °C, days to visible bud and days to flower significantly decreased while height of flowers, vegetative height, and total height significantly increased. As irradiance increased, plant growth increased but little influence on flowering time was observed. *Angelonia angustifolia* appears to be a day-neutral plant with respect to flowering. The influence on growth regulators will also be discussed.

### Effects of Light Sources for Light Period Extension on Growth and Flowering in Statice

Dong-Lim Yoo<sup>1</sup> and Seung-Woo Lee<sup>2</sup>; <sup>1</sup>Horticultural Research Div., National Alpine Agricultural Experiment Station, 232-950, Korea; <sup>2</sup>Department of Horticulture, Kyung Hee University, 449-701, Korea

This experiment was conducted to investigate the effects of artificial light sources for light period extension on growth and flowering of statice 'Sophia' and 'Early Blue'. The seeds were sown on 10 June in a plug tray with 128 plugs. The seedlings were grown at the highland (800 m above sea level) for 50 days, and transplanted on 30 July in 20-cm-diameter plastic pots. High-pressure sodium lamps (HPS) (220V, 400W), incandescent lamps (II) (220V, 200W), and fluorescent lamps (FI) (220V, 40W) for day length extension (16-h photoperiod) as compared with short day (8-h photoperiod) were tested. HPS gave the greatest photosynthetically active radiation (PAR), but FI did the smallest. HPS or FI as compared with II showed high ratio of red/far-red light. The leaves of plant grown under HPS were effective for light absorbance and chlorophyll contents. HPS promoted photosynthesis as much as light period extension, while more respiration than photosynthesis occurred under FI affected by low PAR. Long day condition as light period extension hastened flowering of statice, and HPS or II were more effective than FI on flowering among artificial light sources tested. The light compensation and saturation points of statice were 50 and 500  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ , respectively. Photosynthesis hastened at high temperature, but amount of photosynthesis at vegetative stage showed much higher than flowering stage under the condition below 20 °C. These results indicated that day length extension with HPS increased productivity and quality for cut flower of statice at the highland in Korea.

## 161 ORAL SESSION 30 (Abstr. 635–642) Vegetable Crops: Sustainable Agriculture Wednesday, 26 July, 4:00–6:00 p.m.

635

### Sequential Testing to Determine Optimum Compost Maturity Levels

Kimberly A. Klock-Moore\* and George E. Fitzpatrick; University of Florida, Fort Lauderdale Research and Education Center, 3205 College Ave. Fort Lauderdale, FL 33314

Analytical determination and confirmation of minimum compost processing times and minimum curing times can aid commercial growers in selecting compost materials that should give them more reliable and consistent results in their operations. Five-cubic-yard volumes of yard-trimmings were assembled into three 1.25-cubic-yard compost piles at 60-day intervals. At the conclusion of the experiment, there were three piles each of compost of the following ages: 10 months, 8 months, 6 months, and 2 months. Compost was collected from each pile and screened through a 0.75-inch screen. Bulk density, water-holding capacity, air-filled porosity, carbon to nitrogen ratio, electrical conductivity, and ATPase activity were determined on samples from each reference compost pile. A bioassay using beans also was performed. These data will be presented.

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WITHDRAWN

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### Selecting Rhizoma Peanuts (*Arachis* sp.) for Living Mulch in Vegetable Production in Florida

H.H. Bryan<sup>1</sup>, A.A. Abdul-Bak<sup>2</sup>, L. Carrera<sup>2</sup>, G. Zinati<sup>1</sup>, and W. Klassen<sup>1</sup>; <sup>1</sup>Univ. of Florida, IFAS, Tropical Research and Education Center, 18905 SW 280 St., Homestead, FL 33031; <sup>2</sup>U.S. Dept. of Agriculture, BARC, Beltsville, MD 20705

Ground covers in orchards and living mulches in vegetable fields can be effective in reducing weed control costs and loss of water and nutrients from the soil, fixing N, and adding organic matter to the soil. Several accessions of rhizoma (perennial) peanut were evaluated in 1999, 30 months after planting, at the farm of the Tropical Research and Education Center, Univ. of Florida, Homestead, in gravelly, calcareous soil with a pH of 7.5. Evaluation criteria included adaptability (plant vigor, rhizome growth, and biomass yield), weed suppression, N-fixation,

nutrient content, leaf density, and Fe chlorosis. Accessions that survived exhibited major differences in the evaluation criteria. Accessions No. 6968 and 4222 (recently named 'Amarillo') showed promising potential for use as ground cover and a living mulch in vegetable fields in southern Florida.

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### Intercropping Buckwheat and Sweet Corn: Competition and Management Factors

Danielle D. Treadwell\* and Nancy G. Creamer; Dept. of Horticulture, North Carolina State Univ., Raleigh, NC 27695-7609

Row intercropping sweet corn (*Zea mays* L.) with a living mulch of buckwheat (*Fagopyrum esculentum* Moench) may reduce weed competition without reducing sweet corn yields. The objective of this experiment was to examine competition for nutrients, crop water use, and plant growth between weeds, buckwheat, and organically grown sweet corn, and examine the impact of buckwheat on weed densities and corn yields. In 1999, 'Bodacious' (se hybrid) sweet corn was planted to 41,000 plants/ha stand and the following treatments were applied: 1) 'Manor' buckwheat planted at 0  $\text{kg}\cdot\text{ha}^{-1}$ , 56  $\text{kg}\cdot\text{ha}^{-1}$ , and 112  $\text{kg}\cdot\text{ha}^{-1}$ , 2) buckwheat planted at three times: planting corn, at four-leaf corn and eight-leaf corn stage. A RCB design with four replications including a weedy/weed-free split was used. Above ground biomass of buckwheat was measured within a 1/2-m<sup>2</sup> quadrat 8WAP and analyzed for C and N. Weed densities were taken within a 1/2-m<sup>2</sup> quadrat 4WAP and 8WAP following each buckwheat planting. Buckwheat and corn tissue samples were analyzed for total nutrient content 8WAP. Soil samples were taken in corn and buckwheat interrows at emergence, 4 WAP, 8 WAP, and at harvest, and evaluated for inorganic nitrogen and soil moisture. Within rate treatments, yield was highest in weed and buckwheat-free (16.3  $\text{MT}\cdot\text{ha}^{-1}$ ) and lowest in weed-free 112  $\text{kg}\cdot\text{ha}^{-1}$  buckwheat (8.5  $\text{MT}\cdot\text{ha}^{-1}$ ). Within buckwheat timing treatments, yield was highest in 8 leaf (18.2  $\text{MT}\cdot\text{ha}^{-1}$ ) relative to at plant buckwheat. Weed densities were highest in no buckwheat (281  $\text{no}/\text{m}^2$ ) and lowest in 56  $\text{kg}\cdot\text{ha}^{-1}$  buckwheat (28  $\text{no}/\text{m}^2$ ) compared to the controls. These findings indicate buckwheat rate influences yield and weed density more than timing of buckwheat plant.

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### Tomato Response to Residual Compost and Fertilizers

Alexander A. Csizinszky\*; Univ. of Florida, Gulf Coast Research and Education Center, Bradenton, FL 34203

Tomato, *Lycopersicon esculentum* Mill. 'Asgrow 1035', was planted in Summer–Fall (Aug.–Dec.) 1998 in a land previously amended with compost in Fall 1997 and then cropped in sequence with three vegetables during the Fall–Winter–Spring 1997–1998. Soil was an Eau Gallie fine sand, and the production system was a full-bed polyethylene mulch with micro-(trickle) irrigation. Experimental design was a split-split plot replicated three times. Main plots were N and K fertilizer treatments for the Fall 1998 tomato crop: fertilized (FT 98) or nonfertilized (NF 98). Subplots were two N–P–K treatments for the Fall 1997 tomato crop: fertilized (FT 97) or nonfertilized (NF 97). Sub-subplots were four compost rates 0x, 1x, 2x, and 3x (where 1x = 10  $\text{t}\cdot\text{ha}^{-1}$  'Disneyworld' compost) that were applied for the Fall 1997 tomato crop. Fruit size and yields were best in the plots that received N and K in Fall 1998 (FT 98) and N–P–K in Fall 1997 (FT 97). Early yields (harvests 1 + 2) were highest with the 2x and seasonal total yields (six harvests) were highest with the 3x compost rate. Very high residual soil P and Fe concentrations were detected with increasing compost rates.

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### Developing Fertilizer and Substrate Practices for Organic Greenhouse Tomato Production

Janet F. Miles\* and Mary M. Peet; Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695

'Grace' tomatoes were grown utilizing three different growing methods: organic, conventional, and biorational (IPM and use of reduced-risk pesticides). There was one treatment per greenhouse per growing season. Treatments were rotated for each crop. Inputs for the organic system were allowable according to the Carolina Farm Stewardship Materials List for organic certification or the Organic Material Review Institute (OMRI). Organic methods were compared to conventional and biorational methods in a total of two spring and two fall crops. The conventional and biorational substrates consisted of a commercial peat/perlite blend containing a "starter" nutrient charge. The organic substrates were a coir pinebark blend and a peat/perlite/vermiculite commercial substrate without non-

organic "starter nutrients" and wetting agents. Organic substrates were amended with 15% by volume vermi-compost and dolomitic lime. Organic nutrient amendments were bloodmeal, bonemeal, and potassium sulfate to provide an initial nutrient charge. Organic post-transplant fertilization practices included three commercial blends used at several application rates. Fertilizers were applied by "mixing and pouring" in Spring 1998, but were injected into the drip irrigation system for the remaining three growing seasons. Data was collected on harvest yield, fruit quality, and plant development. In the first two growing seasons, organic production resulted in the highest percentage of number 1 quality fruit, but in Spring 1998, these plants were developmentally slow, resulting in lowest total yields. In the Fall 1998 and Spring 1999 crop, all measurements of growth and yield for organic production were comparable to those in conventional and biorational controls. We feel however, that additional development work is required in the organic treatments to optimize transplant production, post-plant fertilization regimes and biocontrol application.

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### Preliminary Evaluation of Organic Desert Vegetable Production Systems

A. Galadima<sup>1</sup>, C.A. Sanchez<sup>1</sup>, J. Palumbo<sup>1</sup>, B. Ticks<sup>1</sup>, M. Matheron<sup>1</sup>, and M. McGiffen<sup>2</sup>; <sup>1</sup>University of Arizona, Yuma Ag. Center, Yuma, AZ 85362; <sup>2</sup>Dept. of Botany and Plant Science, University of California, Riverside, CA 92521

Experiments were conducted during 1998–99 seasons to evaluate the potential for organic vegetable production in the low desert of the southwestern United States. The experimental design included three summer management options [fallow, cowpea (*Vigna sinensis*), and sudangrass (*Sorghum vulgare*)] in factorial combination with alternative production systems, which included organic and conventional systems. The crops cultivated were iceberg lettuce (*Lactuca sativa* L.) during the fall–winter period and melons (*Cucumis melo* Reticulatus Group) during the spring. The organic plots were managed with strict adherence to California Certified Organic Farmers (CCOF) guidelines. Summer cover crop management seemed to influence the early growth and N uptake of lettuce, but had no final effect on yield and quality. The organic production system resulted in lower yields and inferior product quality compared to the conventional system. Generally, disease and weeds were not limiting factors, although labor costs for weed control would be slightly higher in organic plots. Insects, primarily aphids (various types) and thrips (*Frankliniella Occidentalis* Perancl), and fertility, primarily N, were factors limiting yield and quality in organic systems. Control of whiteflies (*Bemisia argentifolii*) was the limiting factor for melons. Studies during 1999–2000 are focused on overcoming the challenges of the insect and fertility management in organic systems.

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### Three-year Effects of Nitrogen Sources on Plant Component and Yields of Tomato

Wayne F. Whitehead\* and Bharat P. Singh; Agricultural Research Station, Fort Valley State Univ., Fort Valley, GA 31030-3298

This study was conducted over 3 years for the purpose of determining how tomato yield, fruit number, and vegetative dry matter are affected by winter cover crop and recommended fertilizer N rates. The following winter-spring fertility treatments were applied using randomized complete-block design with four replications: 1) 0 N winter–0 N spring, 2) 0 N winter–90 kg N/ha spring, 3) 0 N winter–180 kg N/ha spring, 4) 0 N winter+abuzzi rye–0 N spring, 5) 0 N winter+hairy vetch–0 N spring, and 6) 0 N winter+crimson clover–0 N spring. In Spring of 1996, 1997, and 1999 'Mountain Pride' tomatoes were transplanted in all plots. Total yield was compiled over 6 weeks, while seasonal fruit number and plant dry matter were measured at final harvest. In 1999, highest plant dry matter (350.5 g/plant) was produced by vetch and highest fruit number (36/plant) by 180 kg N/ha. Total yield were highest (85.8 Mg/ha) at 90 kg N/ha in 1996 and lowest (35.3 Mg/ha) for control during 1997. Organic nitrogen from hairy vetch and crimson clover affected plant dry weight, tomato number and yield comparable to those receiving synthetic N. Results over three years for this study indicate that legume cover crops can be an effective N fertilizer in supporting plant dry matter, fruit number and fruit yield of tomato.

## 162 ORAL SESSION 31 (Abstr. 643–650)

### Floriculture/Foliage: Nutrition

Wednesday, 26 July, 4:00–5:45 p.m

643

### The Effect of Nitrogen and Sulfur Applications on Hydrangeas

Willie Helpingstine<sup>1</sup>, Ellen T. Paparozzi<sup>1</sup>, and Walter W. Stroup<sup>2</sup>; Departments of <sup>1</sup>Horticulture and <sup>2</sup>Biometry, University of Nebraska, Lincoln, NE 68583-0724

Hydrangeas are sold as a potted florist plant during the spring, usually around Mothers Day and Easter. They are considered "heavy feeders" because of their high requirement for nitrogen. Two experiments were conducted to determine if the addition of sulfur (S) would allow lower rates of nitrogen (N) to be applied without sacrificing plant color and quality. *Hydrangea macrophylla* 'Blue Danube' were fertilized with four levels of N (50, 100, 200, and 450 ppm) in combination with six levels of S (0, 6, 12, 24, 48, and 96 ppm) during a typical forcing program. The experimental design was a randomized complete block with a complete factorial treatment design. Data collected included visual observations (using the Royal Horticultural Society Color Chart) on leaf color and uniformity of flower color as well as flower shape. Quantitative data included flower diameter, floret diameter, height, and N and S leaf concentrations. Soil pH was monitored throughout the experiment and remained fairly constant (range of 5.0–6.0). Additional sulfur seemed to have no effect on leaf color at the higher levels of N. Lower concentrations of N produced more true blue flower color. Also, at lower N concentrations, higher S resulted in larger flowers with larger florets.

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### Optimum Irrigation and Fertilization Regimes for Ivy Geranium (*Pelargonium peltatum*)

Valerie M. Jonas\* and Kimberly A. Williams; Department of Horticulture, Forestry, and Recreation Resources, Kansas State University, Manhattan, KS 66505-5506

A series of experiments were conducted to determine the ranges of irrigation frequency and N and P fertilization regimes that produce ivy geranium (*Pelargonium peltatum* L.) plants of optimum commercial quality. Two cultivars, 'Sybil Holmes' and 'Amethyst', were grown. Data collected included fresh and dry weights, ratings, leaf area, height, width, ratings, and nutrient tissue content. Individual pots were weighed daily and irrigated when weight of pots dropped by 15%, 30%, 45%, or 60% of container capacity (CC). Leaf water potential was measured using a pressure chamber. At both mid and end of crop, plants irrigated when pot weight dropped by 30% of CC were under least water stress (e.g., water potential of –7.0 to –4.7 MPa). Irrigation frequencies at 15%, 45%, or 60% of CC had similar water potentials (e.g., –9.9 to –9.1 MPa). At 15%, a plausible explanation of the stress is that oxygen was limiting in the root zone due to water-logging; at 45% and 60%, water was the limiting factor. Single factor experiments with N at five concentrations ranging from 2 to 32 mm and P at five concentrations ranging from 0.08 to 2.56 mm were conducted. Quadratic equations were fit to curves of growth responses plotted against concentration of N or P applied. As an example of results, N fertilizer rates of 16 and 32 mm for 'Amethyst' resulted in similar, commercially acceptable dry weights (37g), but different N tissue concentrations of 3.4% and 3.9% respectively. For 'Sybil Holmes', N fertilizer rates of 10 and 26 mm resulted in similar dry weights (21g) but different tissue concentrations of 2.8% and 3.4%, respectively.

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### Foliar Symptomology and Tissue Concentrations of Nutrient Deficient Ornamental Cabbage Plants

James L. Gibson<sup>1</sup>, Brian E. Whipker<sup>1</sup>, Dharmalingam S. Pitchay<sup>1</sup>, Paul V. Nelson<sup>1</sup>, and C. Ray Campbell<sup>2</sup>; <sup>1</sup>North Carolina State University, Dept. of Horticultural Science, Campus Box 7609 Raleigh, NC 27695-7609; <sup>2</sup>North Carolina Dept. of Agriculture, Agronomic Div., 4300 Reedy Creek Road, Raleigh, NC 27607-6465

Elemental deficiencies of N, P, K, Ca, Mg, S, Fe, Mn, Cu, Zn, and B were induced in 'Osaka White' ornamental cabbage (*Brassica oleracea* var. *acephala* L.) plants. Seedlings were planted in 4.7-L plastic containers and fertilized with a complete modified Hoagland's solution or this solution minus the element that

was to be investigated. Plants were harvested for tissue analysis as well as dry weight when initial foliar symptoms were expressed and later under advanced deficiency symptoms. Root architecture was also recorded for the plants treated with the solutions. The containers were replicated three times for each of the two harvests and were randomized in a complete-block design. Deficiency symptoms for all treatments were observed within five weeks. The most dramatic expression of foliar symptoms occurred with N (a purplish tinge on underside of lower foliage leading to necrotic margins on the mature leaves), P (elongated internodes and a purplish tinge on underside of mature leaves), K (compact internodes with chlorotic lower foliage leading to necrotic patches on the leaf margins and blade), Fe (bright yellow upper foliage leading to a bleach white appearance), Ca (complete meristem necrosis with lower foliage becoming chlorotic then necrotic), and B (deformed young leaves and fully expanded leaves becoming thick, leathery, and brittle). The dry weight of plants treated with solutions not containing N, P, Ca, Fe, or B was significantly lower when compared to the control. Foliar tissue concentration data will assist plant tissue analysis laboratories in establishing foliar symptom standards for grower samples.

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### Comparison of Ca and B Deficiency Effects on Growth and Development of Bedding Plants

Dharmalingam S. Pitchay<sup>1</sup>, James L. Gibson<sup>1</sup>, C. Ray Campbell<sup>2</sup>, Paul V. Nelson<sup>1</sup>, and Brian E. Whipker<sup>1</sup>; <sup>1</sup>North Carolina State University, Dept. of Horticultural Science, Campus Box 7609, Raleigh, NC 27695-7609; <sup>2</sup>North Carolina Dept. of Agriculture, Agronomic Div., 4300 Reedy Creek Road, Raleigh, NC 27607-6465

The margin of error in pinpointing the difference in deficiency symptoms between calcium and boron is high. Several experiments were conducted in the greenhouse to induce as well as to differentiate the exact foliar and root symptoms of Ca and B. The experiments were conducted with modified Hoagland nutrient solutions. The treatments were with or without Ca or B salts for inducing total deficiency symptoms. Symptoms were expressed on the upper part including the growing point of the plant. In absence of Ca, marigold and zinnia plant heights were reduced by 58% and 37%, respectively, from the control. However, the reduction in height was only in the 27% and 25% range for B deficiency. Ca deficiency was noted as a blackened region on the leaf blade (early stage symptoms) which progressed into necrotic spots on the newly formed leaves. Severe necrosis, was observed on the growing point with advanced Ca deficiency. B deficiency results in a leathery and gray color in zinnia, needle like and narrow leaflets in marigold. The leaf blades were brittle in all B deficient species. B deficient plants roots were stiff and leathery and lateral roots possessed black nodule like endings at the tips. The Ca deficient roots expressed less side branching and at the advanced stage the roots were shorter and fewer with severe necrotic symptoms. The above initial and advanced deficiency symptoms appeared earlier in treatments without Ca than B. Images of Ca and B deficiency symptoms, as well as tissue concentration values will be presented.

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### Effects of Nitrogen Application Rates on Leachate Nitrogen Concentrations and Leatherleaf Fern Establishment

Robert H. Stamps<sup>1</sup>; MREC, IFAS, University of Florida, 2725 Binion Road, Apopka, FL 32703-8504

One of the most difficult times to balance crop nitrogen (N) requirements with concerns about nitrate-N leaching occurs during crop establishment, when root systems are poorly developed and not widely distributed in the growing medium. This dilemma can be exacerbated when producing a slow-growing plant such as leatherleaf fern (*Rumohra adiantiformis* [Forst.] Ching) on sandy soils in shadehouses in areas with significant rainfall. Rhizomes were planted in 36 drainage lysimeters containing Tavares fine sand located in a shadehouse. Nitrogen fertilizer was applied at nine rates using liquid and/or controlled-release fertilizer. Nitrogen application rates were varied as the rhizomes became established and spread into unplanted areas of the lysimeters. Irrigation and rainfall were monitored and the amount of water not lost to evapotranspiration was determined. Nitrogen (ammoniacal, nitrate/nitrite, total Kjeldahl) concentrations in leachate collected below the rootzone were determined. Stipe sap nitrate and frond total Kjeldahl nitrogen (TKN) were determined to try to develop a production monitoring technique. Initially, only leachate samples from controlled-release fertilizer plots treated at 21 and 42 kg of N/ha per year and liquid fertilizer at 28 kg of N/ha per year were consistently below the maximum contamination level (MCL) of 10 mg·L<sup>-1</sup>. As the fern became established, leachate nitrate/nitrite-N concentrations

from higher N application rate treatments also remained below the MCL. Leachate N concentrations decreased as rainfall increased. Fern growth increased with increasing N application rate. Stipe sap nitrate-N and frond TKN concentrations were not well-correlated during establishment.

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### Assessment of Nitrogen, Phosphorus, Potassium, and Sulfur Pre-plant Nutrients on Plug Seedling Growth

Jin-Sheng Huang\* and Paul V. Nelson; Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Salinity guidelines for seed germination substrates are extremely low and difficult to attain given the salinity contributions of components such as peatmoss, vermiculite, limestone, wetting agent, and nutrients. This study was conducted to determine the value of N, P, K, and S as pre-plant nutrients with the anticipation that some could be eliminated. Seed were sown in two similar experiments on 23 Mar. and 6 June 1995 in 288-cell plug trays containing a substrate of 3 sphagnum peat : 1 perlite (v/v) amended with 6 g dolomitic limestone and 1.5 g Esmigran micronutrient mix per liter. Test plants included impatiens 'Accent Rose' (*Impatiens wallerana* L.) and gomphrena 'Buddy' (*Gomphrena globosa* L.). Six pre-plant treatments including none, all, or all minus one of the nutrients N, P, K, and S were applied, each at a rate of 100 mg·L<sup>-1</sup>, substrate, in a randomized complete-block design with three blocks. Post-plant fertilization with 13–0.9–10.8 at 50 mg N/L began 1 week after sowing and was increased to 100 mg N/L when the fourth true leaf appeared. Omission of pre-plant K and S did not result in any reduction in final plant size in impatiens and only a minor reduction in one of the two gomphrena crops. Omission of N and P consistently reduced final size of plants by a commercially significant amount. While K and S are not necessary, N and P should be considered in a pre-plant fertilizer for these crops. In each situation where shoot size was smaller the root/shoot ratio was unchanged.

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### Post-production Fertility Management of New Guinea Impatiens Hanging Baskets

Donglin Zhang\*<sup>1</sup> and Michael G. Zuck<sup>2</sup>; <sup>1</sup>Horticulture Program, Dept. of BSE, University of Maine, Orono, ME 04469-5722; <sup>2</sup>Everlasting Farm, 2140 Essex Street, Bangor, ME 04401

To grow and sell fully charged hanging baskets to the customers is the future trend of retail markets. *Impatiens xhawkeri* Bull. 'Guadeloupe' (New Guinea Impatiens, Paradise KNG Series) was grown under liquid fertilizer culture until it reached marketable size on 4 June 1999. Then three different fertilizers (two slow-release and one organic) were applied at concentrations of 1.2, 2.4, and 3.6 g pure nitrogen and all hanging baskets were placed in four different family-owned nurseries. Overall performance, media pH, electrical conductivity (EC), and nutrients were measured every 3 weeks and tissue nutrients were analyzed every 6 weeks. New Guinea Impatiens requires low-fertility. Mature plants survived 3 months without extra fertilizer. The best performance was observed under the 3.6 g pure nitrogen treatment. Medium pH ranged from 6.0 to 7.5. No significant effect was observed among the different fertilizers and concentrations. EC increased in the first 6 weeks, then decreased to the beginning level at about 0.5 dS/m after 12 weeks under all fertilizer treatments. Compared with organic fertilizer, slow-release fertilizers had significantly lower EC, especially during the first 9 weeks. Macronutrients in media followed the same trend as EC, as did N and P levels in leaf tissues. K levels in leaf tissues decreased under all treatments and Ca and Mg levels showed an opposite trend compared with medium ones. The results indicate that both slow-release and organic fertilizers can be applied to charge New Guinea Impatiens hanging baskets for 3 months.

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**48 ORAL SESSION (Abstr. 650–651)**  
**Collegiate Branch Oral Competition**  
**Monday, 24 July, 2:00–2:30 p.m.**

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**650**  
**Effects of Drought and Mechanical Brushing on Height of Tomato and Impatiens**

*Kiffnie M. Holt\** and *Paul H. Jennings*; Dept. of Horticulture, Forestry and Recreation Resources, Kansas State Univ., Manhattan, KS 66506

Seeds of tomato 'Big Beef Hybrid' and impatiens 'Sun and Shade White' were sown in 200-cell plug trays and put under cyclic mist to germinate. After 3 weeks, the most uniform seedlings were transplanted to 24-cell flat inserts where they remained for the duration of the experiment. At 5 weeks, plants were arranged for the study with three flats per treatment. The mechanical group was brushed 50 times at 7:00 a.m., 1:00 p.m., and 7:00 p.m. The brushing mechanism was adjusted as needed to account for growth and stimulate only the top 1 to 2 inches of the plants. Water was withheld from the drought plants until water stress symptoms developed. Treatments continued for three weeks. At the termination of treatment, data was only recorded on the eight plants in the middle of each flat to reduce edge effects. Data collected included height, total stem length, total leaf area, and fresh and dry weight of both roots and shoots. Two more replications of the experiment were performed over the next 3 months. As expected, the treated plants were shorter than the controls and had a more compact and sturdy growth habit in all replications. Effects on leaf area, fresh weight, and dry weight were noted and will be discussed.

**651**  
**Educating the Public about the Design and Implementation of Sustainable Landscapes for Low-income Communities**

*Veronda B. Holcombe\** and *Mary T. Haque*; Dept. of Horticulture, Clemson Univ, Clemson, SC 29634

The concept of designing and implementing sustainable landscapes for low-income communities grew from collaboration between several community partners and Clemson Univ. It was our desire to research, plan, design, and implement sustainable landscapes for Habitat for Humanity homes. The primary goal of designing for these low-income homes was to design for sustainability. We wanted our plans to promote energy efficiency, water conservation, and low maintenance costs. These implemented principals would help the homeowner drastically cut living costs. The design and implementation of wildlife habitats was also encouraged to promote knowledge and research on environmental issues. In the beginning of our design phase we interviewed our client about her user needs/ desires and later presented her with the design. This began the exhibition and education phase of the project. By exhibiting the project we hoped to educate the homeowner about the sustainability issues that are pertinent to her case. Our biggest educational outreach program took place during homecoming at Clemson Univ. Partnering with other student organizations and using donated plant material from a local nursery, we constructed gardens and "planted" trees around a Habitat for Humanity house that is built each year during homecoming and later moved by trailer to its final site. We also displayed our designs inside the house and created pamphlets and brochures for visitors to pick up detailing such topics as Butterfly Gardening. Spurred on by the success of this project a web page detailing our community and organizational involvement was created. Our projects have been covered in many newspaper articles, cable TV, and in a video on service learning being produced for national distribution. As a student it has given me and my other student colleagues an opportunity to engage in and acquire valuable hands-on experience in horticulture and environmental education/stewardship all the while providing a much needed public outreach service that assists and partners with community members in order to enhance their personal home environments.

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**76 COLLOQUIUM 2 (Abstr. 652–655)**  
**Global Carrying Capacity—Food and Future World Population**  
**Tuesday, 25 July, 8:00 a.m.–1:00 p.m.**

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**652**  
**Beyond Subsistence: The Prospects and Problems of Horticultural Products in Agricultural Diversification of Developing Countries**

*Raisuddin Ahmed\**; International Food Policy Research Institute (IFPRI), Washington, DC 20006

Transformation of developing, subsistence economies into commercial and industrialized societies accompanies a declining share of agriculture in the gross domestic product (GDP). However, the shares of high-value products like horticultural, livestock and fish products increase with the decline of low-value products like cereals. This process of transformation is generally endogenous to various forces of supply and demand and, therefore, its pace can be influenced by policies. The forces in the demand side include income and income parameters of domestic consumers, and the ability to exploit foreign demand through exports of horticultural products. On the supply side, a large number of factors constrain the production of horticultural products. Agro-ecological constraints are country-specific. Technological backwardness, lack of quality control and standardization, weak marketing infrastructure including risk insurance, comparative advantages and institutional weakness in linking with world markets and exploiting economies of scale are some of the fundamental problems confronted by most developing countries. Export of horticultural products from developing countries is perhaps the most crucial factor that can impact the process of transformation mentioned above. Macro-economic policies that maintain a stable incentive structure for exports are important. But policies that respond to the constraints in the channel linking farmers in developing countries to super-markets in the developed world are perhaps more important. Developing countries currently share only about 27% of world trade in horticultural products. More than 80% of this trade is, however, shared by only 31 developing countries. Barriers to entry into the developed market by new exporters of horticultural products are enormous. Whether the emerging forces of globalization under the auspices of WTO would make the entry problem more difficult or easier for vast majority of the developing countries is an open, but critical, question.

**653**  
**Achieving and Maintaining a Sustainable Agriculture**

*Richard R. Harwood\**; Crop and Soil Sciences Dept., Michigan State Univ., East Lansing, MI 48824

Our farm operations will face an array of challenges over the next decade that are increasing both in scope and intensity. Global markets, global supply, competition for water, land costs driven by the value of non-agricultural use, complexity of regulation, and consumer concern over what they perceive to be safe food are among the many challenges to farm enterprise sustainability. We will have to "contain" our soil, nutrients, crop and animal residues and production inputs within our field boundaries and in the upper layers of soil. We must do all of this while increasing productivity (achieving ever-higher nutrient and crop residue flow) and being cost-competitive. Many exciting advances are being made in engineering as well as in crop genetics. The most far-reaching, however, will be the contributions that will come from other parts of the biological revolution. The science of production ecology is helping us to better understand the myriad of biological and biogeochemical processes that we deal with daily. We are moving toward management of the genetics of pest populations. We will purposefully manage the diversity and amounts of crop residues in our fields which, in turn will control the populations of plants and animals in our soil. We will manipulate the incorporation and release of nutrients from organic fractions in our soil for containment and nutrient recycling. Our nutrient and chemical inputs will be targeted and largely supplemental rather than the direct mainstay of our production. If our production is to be a sustainable part of the landscape we must be seen to provide a high level and quality of hydrological and biodiversity services as part of our management of green space. The more advanced farms have pieces of this future in place now. Numerous examples will be presented from current research, focusing heavily on crop/soil interactions.

### The Role of Plant Genetic Resources in Safeguarding Global Carrying Capacity

*Peter Bretting\**; USDA/ARS, National Program Staff, Beltsville, MD 20705

Plants provide humans with food, fiber, feed, ornamentals, industrial products, medicine, shelter, and fuel. As vegetation, they maintain global environmental integrity and the carrying capacity for all life. From an anthropocentric perspective, plants serve as genetic resources (PGR) for sustaining the growing human population. Research on PGR can provide basic knowledge for crop improvement or environmental management that enables renewable, sustainable production of the preceding necessities. PGR also provide the raw material for increasing yield and end product's quality, while requiring fewer inputs (water, nutrients, agrichemicals, etc.). The staples of life—30 or so major grain, oilseed, fiber, and timber species—comprise the "thin green line" vital to human survival, either directly, or through trade and income generation. Many crop genebanks worldwide focus on conserving germplasm of these staples as a shield against genetic vulnerability that may endanger economies and humanity on an international scale. Fewer genebanks and crop improvement programs conserve and develop "minor crops," so called because of their lesser economic value or restricted cultivation globally. Yet, these minor crops, many categorized as horticultural, may be key to human carrying capacity—especially in geographically or economically marginal zones. The USDA/ARS National Plant Germplasm System (NPGS) contains a great number and diversity of minor crop germplasm. The NPGS, other genebanks, and minor crop breeding programs scattered throughout the world, help safeguard human global carrying capacity by providing the raw genetic material and genetic improvement infrastructure requisite for producing superior minor crops. The latter may represent the best hope for developing new varieties and crops, new crop rotations, and new renewable products that in the future may enhance producer profitability or even ensure producer and consumer survival.

### 655

#### Role of Postharvest Storage in Meeting World Food Needs

*Adel A. Kader\**; Department of Pomology, University of California, One Shields Avenue, Davis, CA 95616, USA

Postharvest losses of horticultural perishables between the production and retail distribution sites are estimated to range from 2% to 23%, depending on the commodity, with an overall average of about 12% of what is shipped from U.S. production areas to domestic and export markets. Estimates of postharvest losses in developing countries are two to three times the U.S. estimates. Losses in dried grains, legumes, nuts, fruits, vegetables, and herbs and spices range from 1% to 10%, depending on their moisture content, temperature and relative humidity of transport and storage facilities, and protection against pathogens and insects. Reduction of these losses can increase food availability to the growing population, decrease the area needed for production, and conserve natural resources. Strategies for loss prevention include use of genotypes that have longer postharvest-life, use of an integrated crop management system that results in good keeping quality of the commodity, and use of the proper postharvest handling system that maintains quality and safety of the products. Biological (internal) causes of deterioration include respiration rate, ethylene production and action, rates of compositional changes, mechanical injuries, water loss, sprouting, physiological disorders, and pathological breakdown. The rate of biological deterioration depends on several environmental (external) factors, including temperature, relative humidity, air velocity, and concentrations of carbon dioxide, ethylene, and oxygen. Socioeconomic factors that contribute to postharvest losses include governmental regulations and policies, inadequate marketing and transportation systems, unavailability of needed tools and equipment, lack of information, and poor maintenance of facilities. Although minimizing postharvest losses of already produced food is more sustainable than increasing production to compensate for these losses, less than 5% of the funding of agricultural research is allocated to postharvest research areas. This situation must be changed to increase the role of postharvest loss reduction in meeting world food needs.

### 158 COLLOQUIUM 3 (Abstr. 656–665)

#### Biotechnology for Harvested Horticultural Crops: Past Accomplishments, Potential Benefits, and Acceptance

Wednesday, 26 July, 2:00–6:00 p.m.

### 656

#### Commercialized Biotechnology, Food for Thought

*E.A. Baldwin\**; USDA/ARS Citrus and Subtropical Products Laboratory, 600 Ave. S NW, P.O. Box 1909, Winter Haven, FL 33883-1909

The promise of biotechnology has been slow to be realized, but some commercialized products are finding their way to supermarket shelves. Nevertheless, the future potential remains in the realm of speculation and may be on the verge of delivering some incredible benefits. Since the world population growth is predicted to double in the next 50 years, primarily in developing nations, food resources will become critical. In view of this prediction, we may need every trick in the book to feed the masses, which means either more land (wetlands, forests, and rain forests) will fall to the plow or there will need to be an increase in yields. Concurrently, a decrease in postharvest losses would also be crucial. Various authorities have estimated that 25% to 80% of harvested fruits and vegetables are lost due to damage and spoilage. Early biotech successes were developing plants with enhanced insect resistance (cotton, corn, and potato) and virus resistance (squash and papaya) and improved herbicide tolerance (cotton, soybean, and corn). The only commercialized transgenic fruit engineered for improved postharvest quality so far is the tomato. Future goals for biotechnology include increasing yield, extending shelf life, improving nutritional and flavor quality, and producing specialty proteins or other compounds. Genetically engineered food, however, has met rancorous resistance in Europe, New Zealand, and elsewhere; although, it is somewhat tolerated in the U.S. The U.S., Canada, and Japan lead the world in biotech acreage, with biotechnology accounting for 40% of cotton, 39% of soybeans, and 20% of corn acreage in the U.S. and 73 million acres worldwide.

### 657

#### Genetic Determinants and Control of Fruit Softening

*Alan B. Bennett\**; Mann Laboratory, Univ. of California, Davis, CA 95616

Fruit softening is integral to the ripening process. It is an important component of fruit quality, but also initiates deterioration and is a limiting determinant of shelf-life. Intensive research has attempted to elucidate the biochemical and genetic control of fruit softening with the goal of controlling this process as a means to enhance both fruit quality and shelf-life. Current models of fruit softening focus on cell wall disassembly as the major biochemical event regulating fruit softening. Examination of the sequence of cell wall disassembly in ripening Charentais melon fruit suggested that softening could be divided into two distinct phases. The early stage of fruit softening was associated with the regulated disassembly of xyloglucan polymers and the later softening that accompanies overripe deterioration was associated with pectin depolymerization. Characterization of cell wall changes in other fruit, including tomato, suggest that this may represent a general model of sequential cell wall disassembly in ripening fruit. Interestingly, the early events of xyloglucan disassembly were not associated with the activation or expression of xyloglucan hydrolases but were associated with the expression of a ripening-regulated expansin gene. Analysis of transgenic tomato fruit with suppressed expansin gene expression or with suppressed polygalacturonase gene expression supports a general model of sequential disassembly of xyloglucan and pectin that control the early and late phases of fruit softening, respectively.

### 658

#### Engineering Ethylene Synthesis and Perception for Fun and Profit

*Harry Klee\**, Univ. of Florida, Horticultural Sciences Dept., Plant Molecular and Cellular Biology Program P.O. Box 110690 Gainesville, FL 32611

Ethylene-based technologies for controlling ripening in climacteric fruit have been in widespread use for a number of years. Likewise, using chemicals that

block ethylene synthesis or perception have been widely used to extend shelf life of a variety of horticultural commodities. In the last few years, our understanding of the molecular mechanisms for ethylene synthesis and perception has greatly expanded. Genes encoding the ethylene biosynthetic enzymes and the ethylene receptor have been cloned from many plant species, which has meant that molecular approaches to engineering reduced ethylene synthesis or perception are now reality. Scientists have been examining the feasibility of using molecular approaches to control ethylene in a variety of horticultural and ornamental species. They have shown that it is relatively easy to produce plants that are reduced in either synthesis or response to ethylene. However, scientists have uncovered some issues associated with commercial-level use of these transgenic plants. Overall, my results illustrate the great potential of the technology to control the rate of climacteric fruit ripening, abscission, and ethylene-induced senescence in multiple species, but using transgenes in many cases needs to be directed to target tissues through the use of tissue-specific transcriptional promoters. With that caveat in mind, there should be a strong future for improving the quality of a range of agronomic and horticultural species.

659

### Genetic Control of Fruit Quality and Prospects for Nutrient Modification

*Jim Giovannoni\**; Department of Horticultural Sciences and Crop Biotechnology Center, Texas A&M University, College Station, TX 77843-2133

Recent advances in molecular genetics and genomics technologies have had a significant impact on tomato research over the last decade and are likely to have considerable influence on the nature and outcome of research activities related to tomato in the future. Specific applications of genomics technologies in our laboratory include positional cloning of genes associated with fruit ripening and quality (*rin* and *nor*), localization of ripening-related genes on the molecular-marker map to assist candidate gene discovery related to fruit ripening and quality, and characterization of mutants influencing fruit quality and nutritional value with the goal of identifying candidate genes for said mutants and alternative molecular tools for modification of fruit quality and nutrition. Isolation of the *rin* and *nor* genes has been verified via complementation of corresponding mutant tomato plants via insertion of the appropriate CaMV35S-driven wild-type sense cDNA. Both the *rin* and *nor* genes have sequence characteristics suggestive of transcription factors. Preliminary evidence suggests the role of similar genes in the ripening of additional climacteric and non-climacteric fruit species. Additional efforts in the laboratory include molecular analyses of light signal transduction as related to 1) regulation of carotenoid and flavonoid accumulation, and 2) potential manipulation of corresponding pathways for modification of fruit quality and nutrient value.

660

### Production of Therapeutic Proteins in Transgenic Plants and Viral Vectors

*John Hammond\**; USDA/ARS, U.S. National Arboretum Floral and Nursery Plants Research Unit, B-010A Room 238, 10300 Baltimore Ave., Beltsville, MD 20705

Transgenic plants and plant viruses have potential advantages over other production systems for therapeutic proteins. 1) Plants are not susceptible to human and animal pathogens, such as viruses that can contaminate mammalian and avian cell lines used for production of many vaccines. Recent experiences of "mad cow" disease and theories of the possible origin of HIV from monkey cell lines have highlighted the need for increased product safety. 2) There are established protocols for preparing naturally occurring pharmaceuticals from plants. 3) Unlike bacteria, plants recognize the same glycosylation signals as other eukaryotic expression systems such as mammalian, insect, or yeast cell cultures and can thus produce glycosylated proteins. Although there are differences between plants and other eukaryotes in the types of sugar residues added to glycosylated proteins, it has been demonstrated several times that plant-produced proteins have similar stability and bioequivalence of function and that antigenicity is similar. 4) Plants can produce high yields; a single transgenic plant could yield as much human glucocerebrosidase as 500 placentae. We expressed an epitope from HIV-1 on the surface of bean yellow mosaic potyvirus (BYMV) coat protein (CP); protein produced in transgenic plants is recognized by a human monoclonal antibody that neutralizes most HIV-1 isolates. Epitope-modified BYMV-CP can be recovered from transgenic plants by incorporation into BYMV virions following infection of the transgenic plants. Modified virions display the HIV-1 epitope in a semi-regular array that should stimulate the immune system

to a greater degree than free subunits. HIV epitope-bearing BYMV has been used to immunize mice to assess the immune response.

661

### Molecular Biology of Host-Pathogen Interactions in Harvested Horticultural Crops

*T.G. McCollum\**; USDA, ARS, USHRL Ft. Pierce, FL 34945

Decay caused by fungal pathogens accounts for significant postharvest losses. Although the application of synthetic fungicides can reduce postharvest decay, increasing public concern over using fungicides as well as the resistance that develops to them indicate that alternative means of decay control are needed. Freedom from disease before harvest is the norm rather than the exception. Numerous defense mechanisms, both preformed and inducible, are involved in plant resistance to fungal pathogens. Understanding how natural defense mechanisms are regulated and how to maintain them in harvested products may provide the basis for new strategies to reduce postharvest losses caused by pathogens. Host-pathogen interactions have been well studied in growing plants but much less extensively in harvested organs. The interaction between host and pathogen is dynamic; changes in both organisms are required for disease development. Following harvest, the incidence of decay increases indicating that changes in the host render it more susceptible to pathogen development. Recent studies by plant physiologists and pathologists have contributed to our understanding of changes in harvested tissues that render them less resistant to decay as well as changes in the host that are induced in response to fungal infection.

662

### Molecular Mechanisms and Potential Control of Abscission in Horticultural Crops

*J.K. Burns\*, C. Arias, I. Kostenyuk, and M. Obraztova*; Citrus Research and Education Center, University of Florida, 700 Experiment Station Road, Lake Alfred, FL 33850

The process of abscission results in shedding of plant parts such as leaves, fruit, flowers, and in citrus, shoot tips and entire shoots. Growers must successfully manage abscission in their operations to avoid unnecessary defoliation or loss of yield due to floral abscission or preharvest fruit drop. Conversely, abscission enhancement may be desired during harvest. Yet despite its importance to horticulture, little is known about mechanisms that control abscission. We know that abscission can be induced by ethylene and altered to some extent by auxin. Over the years, many physiological and anatomical events of abscission have been described. For example, cellulase, polygalacturonase and pectin methylesterase genes are induced during abscission, and they are thought to have a role in alteration and depolymerization of middle lamella polysaccharides located in the abscission zone area. Other genes, such as those associated with the process of pathogen resistance, are also induced during abscission. We are interested in using tools of molecular biology to examine abscission-related gene expression prior to organ separation in Florida field-grown Valencia orange (*Citrus sinensis* L. Osbeck) and greenhouse-grown calamondin (*Citrus madurensis* Loureiro) citrus trees. Subtractive cDNA library screening and differential display were used to examine gene expression in fruit, leaf and floral abscission zones 6, 24 and 48 h after induction of abscission with 5-chloro-3-methyl-4-nitro-1H-pyrazole or Ethrel® (Rhone-Poulenc, [2-chloroethyl] phosphoric acid). Some isolated cDNAs encoded polypeptides with no significant matches in the database or share significant similarities with unknown proteins isolated from Arabidopsis. Other cDNAs encoded polypeptides with similarity to cell wall modifying proteins such as polygalacturonases and expansin, PR proteins such as chitinase, proteins associated with secondary and xenobiotic metabolism such as amine oxidase, benzoquinone reductase, caffeic acid methyltransferase, phenylalanine ammonia lyase and squalene synthase, and proteins associated with signal transduction such as several serine/threonine kinases. Temporal and spatial expression of these genes and others will be presented. Use of this information to target potential points of abscission control will be discussed.

663

### Biochemical and Molecular Determinants of Floral Senescence

*William R. Woodson\**; Dept. of Horticulture and Landscape Architecture, Purdue Univ., West Lafayette, IN 47907-1140

The senescence of carnation (*Dianthus caryophyllus*) flower petals is regulated by the phytohormone ethylene and is associated with the expression of a



number of senescence-related genes. These genes encode enzymes in the ethylene biosynthetic pathway, including both ACC synthase and ACC oxidase. Members of these gene families are differentially regulated in floral organs, with specific members responsible for the increase in ethylene biosynthesis that leads to petal senescence. Pollination often serves as the external signal to initiate the senescence cascade. Following pollination, a rapid increase in ethylene production by the pistil occurs, which is subsequently followed by increased ethylene in the petal. This response is mediated by pollen–pistil interaction(s) that occurs only in compatible pollinations. Recent data indicate that the signal transduction cascade following this cell-cell communication involves protein phosphorylation, as pollination-induced ethylene is sensitive to protein kinase and phosphatase inhibitors. To date, our lab has cloned and characterized a number of senescence-related genes that are believed to play a role in the process of senescence. These include genes that encode enzymes involved in cell wall dissolution (b-galactosidase), protein degradation (cysteine proteinase) and detoxification of breakdown products (glutathione s-transferase). Many of these senescence-related genes are under the transcriptional regulation of ethylene, which has been characterized at the molecular level. A number of biotechnology approaches to controlling the senescence of flowers have been explored. These include the down-regulation of ethylene biosynthetic genes, the expression of a dominant-negative mutation of the ethylene receptor gene, and the expression of genes that lead to increased cytokinin levels in tissues. These will be discussed in relation to the potential for delaying senescence through genetic engineering.

664

#### **A Breeders Perspective Using Molecular Techniques for Improving Fruit Quality**

*J.W. Scott\**, Univ. of Florida, IFAS, Gulf Coast Research and Education Center, 5007 60th St., Bradenton, FL 34203

Plant breeders would welcome new tools to improve selection efficiency for complex traits such as improved flavor, especially since this is only one of many complex traits that a breeder has to integrate into improved cultivars. Using tomato (*Lycopersicon esculentum* Mill.) flavor as an example, a major obstacle to improvement is the lack of measurable traits to select for. It has been suggested that improved flavor can be achieved by increasing the soluble solids and acidity. Both of these traits are not simply inherited, but if fruit sampling is adequate, they can be measured and selected. Studies have located several molecular markers linked to high soluble solids, but some are also linked to undesirable traits such as small fruit size or low yield. Thus, the molecular markers are not being used in breeding programs at this point. Moreover, other studies have shown that flavor is also influenced by an array of aromatic volatiles. The importance of some of the volatiles has been reported, but the volatile profile that consistently results in superior tomato flavor is still not known. Molecular manipulation of a biochemical pathway has been done to increase the concentration of one volatile with positive results. However, this manipulation does not solve the overall flavor improvement problem. Furthermore, environment plays a profound role in tomato flavor, and this aspect needs to be dealt with if a branded high-quality product is to be successfully marketed. There are also flavor issues related to fruit firmness, pedicel type, and plant habit. In summary, molecular techniques may be useful in providing some incremental improvements for complex traits like tomato flavor, but more knowledge about targets to manipulate is required. There does not appear to be any cheap or easy solutions. If molecular approaches are to be commercially successful, they will have to be tied closely to a breeding program dedicated to the same goal.

665

#### **Opportunities in Using Biotechnology to Maintain Postharvest Quality and Safety of Fresh Produce**

*Adel A. Kader\**, Department of Pomology, University of California, One Shields Avenue, Davis, CA 95616, USA

Biological factors involved in deterioration of fresh horticultural perishables include respiration rate; ethylene production and action; compositional changes associated with color, texture, flavor (taste and aroma), and nutritional quality; growth and development; transpiration; physiological breakdown; physical damage; and pathological breakdown. There are many opportunities to modify these inherent factors and to develop genotypes that have lower respiration and ethylene production rates, less sensitivity to ethylene, slower softening rate, improved flavor quality, enhanced nutritional quality (vitamins, minerals, dietary fiber, and phytonutrients including carotenoids and polyphenols), reduced browning po-

tential, decreased susceptibility to chilling injury, and increased resistance to postharvest decay-causing pathogens. In some cases the goals may be contradictory, such as lowering phenolic content and activities of phenylalanine ammonialyase and/or polyphenoloxidase to reduce browning potential vs. increasing polyphenols as antioxidants with positive effects on human health. Another example is reducing ethylene production vs. increasing flavor volatiles production in fruits. Overall, priority should be given to attaining and maintaining good flavor and nutritional quality to meet consumer demands. Extension of postharvest life should be based on flavor and texture rather than appearance only. Introducing resistance to physiological disorders and/or decay-causing pathogens will reduce the use of postharvest fungicides and other chemicals by the produce industry. Changes in surface structure of some commodities can help in reducing microbial contamination, which is a very important safety factor. It is not likely that biotechnology-based changes in fresh flowers, fruits, and vegetables will lessen the importance of careful and expedited handling, proper temperature and relative humidity maintenance, and effective sanitation procedures throughout the postharvest handling system.

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## **26 WORKSHOP 1 (Abstr. 666–671) Horticulture Across the Pacific Monday, 24 July, 8:00–10:00 a.m.**

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666

#### **Lychee Production and Postharvest Technologies in China**

*Weixin Chen\**, Department of Horticulture, South China Agricultural University, Guangzhou, P.R. China

Lychee is a well-known subtropical fruit, much appreciated for its attractive red peel and excellent taste, but the fruit is very prone to postharvest peel browning and decay. China is the world leader in both acreage and yield of lychee production. Extensive research has been conducted to extend the fruit quality and shelf life. The talk presents a general review of the current research on postharvest physiology and shelf life preservation technologies of lychee in China.

667

#### **Off-season Production of Horticultural Crops**

*Hsin-Shan Lin<sup>1</sup> and Chien Yi Wang<sup>2</sup>\**, <sup>1</sup>Miaoli District Agricultural Improvement Station, 261 Kuan-Nan Village, Kung-Kuan, Miaoli, Taiwan 383; <sup>2</sup>USDA/ARS, Building 002, BARC-West, Beltsville, MD 20705

Off-season production of several tropical and subtropical fruits has been successfully practiced commercially in Taiwan. By combining pruning, removal of leaves, and application of growth regulators, it is possible to have two to three crops of grapes per year. By grafting the chilled scions of temperate Asian pear onto the water shoots of low-chilling native pear varieties, it is possible to produce high-quality Asian pears (temperate-origin) in a subtropical environment. By using techniques such as root-pruning, flooding, and application of growth inhibitors, it is possible to induce flower bud formation and hasten the production of wax apples. The production periods of other fruit crops such as jujubes and sugar apples, can also be modified by pruning and other techniques.

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#### **The ASHS/People-To-People Mission to China**

*Donald N. Maynard\**, University of Florida, 5007 60th St. East, Bradenton, FL 34203

The Citizen Ambassador Program was initiated in 1956 when President Dwight D. Eisenhower founded "People to People." His vast perspective as a military and governmental leader led him to believe that individual citizens reaching out in friendship to the people of other nations could make a significant contribution to world understanding. From 14–28 Aug. 1998, ASHS took part in the "People-to-People Mission to China." Our delegation was composed of six ASHS Members and two guests. Delegates were from Canada and Brazil and the United States. After meeting in Los Angeles for a final briefing, the delegation departed for Hong Kong, where we immediately boarded a flight to Beijing. Our China experience began in Beijing, then on to Hangzhou, Shanghai, Guangzhou, and Hong Kong. All of these locations are in the densely populated eastern portion of China. (China has approximately the same area as the United States, but it has 1.25 billion

people compared to only 270 million in the U.S.) Our time at each location was about equally divided between professional and cultural activities. Our Chinese horticultural colleagues were enthusiastic and well-trained. As in the United States, the quality of the facilities and the equipment varied somewhat among locations. Operating funds, never sufficient for research and maintenance of facilities, commonly were supplemented by sale of horticultural products.

669

### Greenhouse Vegetable Production in China

*Guanghua Zheng\**; Chinese Academy of Agricultural Sciences, Institute of Vegetables and Flowers, Chinese Academy of Agricultural Sciences, 30 Baishiqiao Road, Beijing, P.R. China, 100081

There was a remarkable growth in China's greenhouse horticulture during the past decade. In 1989, the greenhouse area in China was 22,000 ha, but this figure reached up to 350,000 ha in 1999, about 16 times as large as that in 1989. Currently, the main greenhouse design used for commercial production is the energy conservation type—solar greenhouse—and many growers use eco-organic soil-less culture for production. The substrates used for vegetable production are perlite, vermiculite, peat, coal cinder, sand, coir, sunflower stem, and sugar cane stem. Dry solid organic manure is mixed into the substrates before conducting cultivation, and then only water is for irrigation. Growing vegetables in this way improved quality, increased market value, and decreased environmental pollution.

670

### Development and Current Situation of the Flower Industry in China

*Liang-jun Zhao\**; Department of Ornamental Horticulture, China Agriculture University, Haidian, Beijing, P.R. China

Technological achievements of the flower industry since 1978 in China are summarized into six sections, which include 1) main ornamental plant germplasm resources and its utilization; 2) introduction, improvement and propagation of new cultivars; 3) flower seed industry. The development trends and problems of the flower industry are also analyzed, especially in the flower seed industry.

671

### Genetic Diversity in Actinidia and Conservation Strategy

*Hongwen Huang\**; Wuhan Institute of Botany of Chinese Academy of Sciences, Moshan, Wuchang, Hubei, 430074, P.R. China

The genus *Actinidia* contains more than 66 species and 118 taxa. The best-known species is *A. deliciosa* C.F. Liang et A.R. Ferguson, the commercially developed kiwifruit. The natural range of *Actinidia* is remarkably wide, extending from the tropics (latitude 0°0') to cold temperate regions (500°N). However, the original distribution of most taxa of *Actinidia* is centered around the mountains and hills of south-central and southeast China, with the QinLing mountain as its northern boundary and the HengDuan mountain as its western boundary. Sixty-two species, 114 taxa have been found in China. Genetic variation ranging from morphological traits to DNA is discussed in here. 1) Morphological variation (mainly horticulturally important traits): fruit size varies from 2 to 100 g, fruit skin color ranges from brown to green to white to purple, fruit surface from setose to villose, and flesh color from green to purple. 2) Nutritional value and flavor: vitamin C content varies from 10 mg/100 g to 1000 mg/100 g fresh fruit, soluble solids ranges from 2% to 22%, and flavor includes variation from bitter and astringent to desirable sour-sweet. 3) Gender variation includes six phenotype/genotypes of female, inconstant female, male, fruiting male, neuter and hermaphrodite. 4) Ploidy variation is consist of 2x, 4x, 6x, 8x in both intra- and inter-taxa variation. 5) Isozyme genetic variation: high polymorphisms were detected in commercial cultivated species and 28 wild species. 6) Genetic diversity was evaluated by RAPD, SSR, PCR-RFLP of mtDNA and cpDNA, a high level of genetic diversity was found in both inter-taxa and intra-taxa. Conservation strategy for diverse genetic resources of *Actinidia* in China is also discussed.

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## 34 WORKSHOP 2 (Abstr. 672–673)

### Nutrient Balances in Horticultural Ecosystems: Optimizing Fertilization and Maximizing Environmental Protection

Monday, 24 July, 10:00 a.m.–12:00 noon

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672

### Modelling Nutrient Use by Tree Crops, Development of a Computer-based Fertilization Program

*Patrick H. Brown\**; Department of Pomology, University of California, Davis, Davis, CA 95616

The aim of this research was to determine the seasonal patterns of N demand and uptake in mature almond trees and to use this information to develop an integrated computer model to guide fertilization management. To this end sequential whole tree excavations were conducted at 5 stages during a 15-month period. At each harvest date, five entire mature trees were excavated and partitioned into leaves, root, trunks, and branches. Samples were then analyzed for total nutrient content and differences in nutrient content between sequential harvests, which represents tree nutrient demand and tree nutrient uptake. Information on seasonal N uptake dynamics and total yearly N demand has now been integrated into a user-friendly interactive computer program that can be used to optimize N fertilizer management. The details of this program will be discussed. In summary, the determination of N fluxes in almond demonstrates that the majority of N uptake and demand occurs from late February through to early September and that the primary demand for N is for nut fill and nut development. N demands can therefore be predicted by estimating yield and can be applied during the periods of greatest N uptake from the soil which occurs during nut development. By timing N applications with periods of greatest demand, and matching N application rates with crop load we provide growers with a tool that will encourage maximum efficiency of use of N fertilizers. Maximum efficiency of use will result in a minimization of N loss from the orchard system.

673

### A Synthesis of Worldwide Approaches for Rationalizing Nitrogen Fertilization of Vegetable Crops

*N. Tremblay\** and *C. Bélec*; Horticultural R&D Center, Agriculture and Agri-Food Canada, St-Jean-sur-Richelieu, Qc, Canada, J3B 3E6

The necessity of achieving appropriate nitrogen fertilization of vegetable crops relates to both economical and environmental sustainability. Split nitrogen applications have been shown to improve N-use efficiency, in line with the aforementioned objective and should therefore be encouraged. Given the variation in the amount of N naturally provided to, or uptaken by, the crop, strategies are required to tailor supplementary fertilization to actual crop needs, keeping in mind the absolute requirement for optimal yield in quality and quantity. It is suggested that the fertilization rates applied at sowing or later in the season can be figured in two manners. The first relies on modelling; the second on measurements. The modelling (N budget) approach, mostly linked to initiatives on the European continent, would be most applicable to the determination of the first fertilizer dressing. When a plant stand is established, however, canopy-based measurements made either directly or remotely could be developed to make use of the capability of the plants to integrate the properties of the soil environment and to decide upon further top-dressed applications. For this purpose, a fully fertilized "reference plot" has to be introduced in the field in order to overcome the variability induced by season, site and cultivar. With the emergence of "precision farming" and "remote sensing technologies" it is now possible to adjust fertilizer inputs not only at the field level but also within fields based on actual, localized requirements.

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**35 WORKSHOP 3 (Abstr. 674–677)**  
**Horticultural Aspects of Phytochemicals in**  
**Small Fruits**  
**Monday, 24 July, 10:00 a.m.–12:00 noon**

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**674 Horticultural Aspects of Phytochemicals in Small Fruits: Introduction to the Workshop**

*Fumiomi Takeda\**: USDA/ARS, Appalachian Fruit Research Station, 45 Wiltshire Road, Kearneysville, WV 25430

Small fruits, such as strawberries and blueberries, are rich in phytonutrients and regarded to have high human health-functional bioactivities. In this workshop, 1) the horticultural and environmental factors affecting antioxidant levels in small fruit, 2) fruit volatiles as related to postharvest shelf life and quality, 3) changes in non-volatile fruit constituents, and 4) olfactometric analyses and consumer perception of these value-added fruit constituents will be discussed. In addition, novel detection methods for fruit- and microbial-derived aromas to address the food safety issues will be discussed.

**675 Horticultural Factors Affecting Anthocyanin and Phenolic Content and Antioxidant Capacity of Small Fruit**

*W. Kalt\*, J.E. McDonald, and S. MacKinnon*: Agriculture and Agri-Food Canada Research Centre, Atlantic Food and Horticulture Research Centre, 32 Main St., Kentville, Nova Scotia, B4N 1J5, Canada

Fruit and vegetable components that possess antioxidant capacity are being actively investigated because of the purported impact of dietary antioxidants on human health. Phenolic components, including anthocyanins, are believed to be major contributors to the antioxidant capacity of many small fruit species. Various horticultural factors have been examined with respect to anthocyanin and phenolic content, and antioxidant capacity of small fruit, especially *Vaccinium* species. *Vaccinium* species, and certain other fruits, had a high antioxidant capacity compared to strawberries and raspberries. However, genotypic variation in these characteristics was substantial among wild blueberry clones. Fruit maturity did not influence antioxidant capacity, although phenolic profiles changed dramatically during ripening. Fresh storage of certain ripe fruit at 20 °C led to increased anthocyanin content and increased antioxidant capacity. Certain food processing factors, such as heat and oxygen, decreased the antioxidant capacity of blueberry products.

**676 Effects of Volatiles on Postharvest Shelf Life and Quality**

*Charles F. Forney\**: Agriculture and Agri-Food Canada, Atlantic Food and Horticulture Research Centre, 32 Main Street, Kentville, Nova Scotia B4N 1J5 Canada

Volatile compounds make a significant contribution to the quality and storage life of fresh strawberries, blueberries, and raspberries. Strawberry aroma is composed predominately of esters, although alcohols, ketones, and aldehydes are also present in smaller quantities. The major volatiles contributing to aroma include ethyl butanoate, 2,5-dimethyl-4-hydroxy-3(2H)-furanone, ethyl hexanoate, methyl butanoate, linalool, and methyl hexanoate. In lowbush (wild) blueberries, aroma is predominated by esters and alcohols including ethyl and methyl methylbutanoates, methyl butanoate, 2-ethyl-1-hexanol, and 3-buteneol, while highbush blueberry aroma is dominated by aromatic compounds, esters, terpenes and long chain alcohols. The aroma of raspberries is composed of a mixture of ketones and terpenes, including damascenone, ionone, geraniol, and linalool. The composition and concentration of these aroma compounds are affected by fruit maturity and storage conditions. As fruit ripen, the concentration of aroma volatiles rapidly increases. This increase in volatile synthesis closely follows pigment formation both on and off the plant. In strawberry fruit, volatile concentration increases about 4-fold in the 24-h period required for fruit to ripen from 50% red to fully red on the plant. In storage, volatile composition is affected by storage temperature, duration, and atmosphere. Postharvest holding temperature and concentrations of O<sub>2</sub> and CO<sub>2</sub> can alter the quantity and composition of aroma volatiles. The effects of postharvest environments on volatile composition will be discussed.

**677 Fruit Quality and Non-volatile Constituents in Small Fruits**

*P. Perkins-Veazie\**: USDA/ARS, SCARL, Lane, OK 74555

Small fruit share several general characteristics. A significant source of starch is missing in strawberry, blueberry, cranberry, raspberry, blackberry, and grapes; thus, sugars accumulated at time of harvest represent the maximum amount of sweetness available. Total non-volatile acids decrease or stay the same, depending on the fruit. Immature small fruit are astringent, due to the presence of a variety of phenolic compounds that are diluted, metabolized, or immobilized in mature fruit. Ripeness can be determined by obvious changes in color, coinciding with or prior to fruit softening. Berry color is governed by the loss of chlorophyll and the accumulation of water soluble flavanoids and anthocyanins, rather than through accumulation of fat-soluble carotenoids. Environmental changes, especially temperature and rainfall, affect sugars, acidity, and color while storage conditions are more likely to affect color and acidity.

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**53 WORKSHOP 5 (Abstr. 678–679)**  
**How to Get that International Experience**  
**You Want (and Still Keep Your Day Job!)**  
**Monday, 24 July, 2:00–5:30 p.m**

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**678 How To Participate in the Fulbright Experience (and a Brief Summary of My Recent Fulbright Experience at Africa University, Zimbabwe)**

*John L. Griffis, Jr.\**: Dept of Citrus & Environmental Horticulture, Florida Southern College, Lakeland, FL 33801

For more than 50 years, the Fulbright Scholar Program has offered U.S. faculty, professionals, teachers, and students the opportunity to conduct research, teach, or study abroad and to make a major contribution to global understanding. The purpose of the program is "... to increase mutual understanding between the people of the United States and the people of other countries... and thus to assist in the development of friendly, sympathetic, and peaceful relations between the United States and other countries of the world." There are more than 700 competitive Fulbright awards in more than 120 countries available each year. The majority are for lecturing or combined lecturing/research, although some research-only awards are also available. Eligibility for awards as well as an overview of available opportunities will be discussed. Application procedures and techniques useful in securing awards will also be presented. I received a Fulbright award to lecture in horticulture at Africa Univ. in Zimbabwe during 1997, and will provide a brief summary of my Fulbright experience.

**679 Freelance Consulting in Tropical Agriculture**

*Carl W. Campbell\**: Tropical Research and Education Center, IFAS, Univ. of Florida, Homestead, FL 33031-3314

During a 30-year career of research, extension, and teaching in tropical fruit production, I participated frequently in international agricultural activities in countries of Central America, South America, and the Caribbean region. In 1988, I retired from the Univ. of Florida to begin a "second career" as a freelance consultant in tropical fruit production and crop diversification, working for a variety of governmental and private organizations. This presentation contains suggestions for horticultural scientists who wish to become involved in consulting in international agriculture. First, decide the kind of work you wish to do and what your area of specialization will be. Choose work for which you have enthusiasm. Get training in basic as well as applied science. It is good to have a "day job," at least at first, as you establish a reputation in your specialty. Become proficient in the languages of the regions where you wish to work; also carefully study the cultures. When you participate in an international project, work hard and prepare good reports of your accomplishments. As your career progresses, consider carefully whether or not you will become a full-time consultant. It is a demanding way to make a living, but it can also give much satisfaction and greater independence than one finds in many other kinds of work.

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**64 WORKSHOP 8 (Abstr. 680)**  
**Innovative Strategies in Horticulture**  
**Marketing**  
**Monday, 24 July, 4:00–6:30 p.m**

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**680**  
**Innovative Methods to Market Locally Grown Products**  
*Wen-fei L. Uva\**; Dept. of Agricultural, Resource, and Managerial Economics, Cornell Univ., Ithaca, NY 14853

The development of industrialized production and global sourcing has changed the marketing structure of the horticulture industry dramatically. The inherent disadvantaged resource base (soils and climate) and high production costs in the northeast United States make it difficult for growers to compete in commodity markets. Exploiting niche and value-added markets are important for the survival of northeast agriculture. Moreover, an emphasis on quality of life has created a movement towards sustainable agriculture. As a result of this movement, many programs have been initiated to promote locally grown products and to support agricultural-based economic development. The common objectives of the "locally grown" programs are to promote agricultural products produced within the region, support the local economy, and develop agricultural markets. Keys to success of a "locally grown" program are a vision, seed funding, a champion, and community, political leadership and technical support. Many innovative regional food and agriculture development programs have been initiated in New York State to support local farmers, revitalize the rural economy, promote local identity and pride, develop agri-tourism, and capture the urban markets. Some examples include the "Finger Lakes Culinary Bounty" initiated by local chefs, "Uncork New York" sponsored by the wine industry, and "Hudson Valley Harvest" and a pilot ethnic market project targeting New York City markets.

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**78 WORKSHOP 10 (Abstr. 681)**  
**Options and Outlook for Managing Water**  
**Stress in Horticultural Crops: Key**  
**Questions**  
**Tuesday, 25 July, 8:00–10:00 a.m.**

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**681**  
**Controlling Stress in Container-grown Plants**  
*Jack W. Buxton\**; Dept. of Horticulture, Univ. of Kentucky, Lexington, KY 40546

The controlled water table irrigation system (CWT) consists of a capillary mat placed on a level bench so one side extends over the edge of the bench into a trough containing a nutrient solution maintained at a controlled distance below the bench. The nutrient solution is drawn by capillarity up to and over the bench surface. As plants use the nutrient solution or as water evaporates from the media, it is replaced from the trough. The automatic system maintains a constant air/water ratio in the growing media. Study 1: Geraniums were grown in 15-cm pots at 0, 2, and 4 cm CWT. Geraniums at 0 and 2 cm CWT had the greatest leaf area and dry weight. Plants at 0 and 2 cm CWT were more than 25% greater at 4 cm CWT. The roots of plants at 0 cm CWT were concentrated at 2 to 4 cm above the bottom of the container; whereas roots at 2 cm CWT uniformly extended from the center to the bottom. Study 2: Water potential in a coarse and fine textured media was determined at the bottom, middle and top of the container at 0, 2, and 4 cm CWT every 2.5 h during the light period. Water potential was about the same in each media within each CWT treatment. At the container bottom at 0 CWT water potential was 0; whereas the water potential at 2 and 4 CWT was lower. The water potential from top to bottom decreased slightly about mid afternoon on a sunny day when water demand was the greatest. The CWT system is potentially a commercially adaptable irrigation system for container crops. It also is a cheap, reliable tool for studying water stress on the crop growth and quality.

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**86 WORKSHOP 11 (Abstr. 682–684)**  
**Dynamics of Fruit Growth**  
**Tuesday, 25 July, 10:00 a.m.–12:00 noon**

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**682**  
**New Perspectives on the Influence of Mid-season Environment on Apple Fruit Characteristics**  
*D.S. Tustin\**<sup>1</sup>, *T. Fulton*<sup>2</sup>, and *H. Brown*<sup>2</sup>; <sup>1</sup>HortResearch, Hawkes Bay Research Centre, Private Bag 1401, Havelock North, New Zealand; <sup>2</sup>National Climate Laboratory, HortResearch, Batchelar Research Centre, Private Bag 11030, Palmerston North, New Zealand

Growth of apple fruit can be described as an initial exponential phase lasting the 40+ days of fruit cell division followed by a more-or-less linear phase where growth is by cell expansion. Temperature is a major influence on fruit growth rate during the cell division phase, thereby affecting fruit size at maturity. However it is generally thought that temperature has less-direct impact on fruit development during the fruit expansion phase. Our observations of apple growth among regions and seasons of considerable climatic variability led us to speculate that temperature may impact directly on fruit development during fruit expansion but that responses may be interactive with carbon balance (crop load) influences. Controlled environment studies are being used to examine this hypothesis. Potted 'Royal Gala' trees set to three levels of crop (one fruit per 250, 500, or 1000 cm<sup>2</sup> leaf area) were grown from 56 to 112 DAFB in day/night temperature regimes of 18/6, 24/12, and 30/18 °C. All trees grew in field conditions prior to and following the controlled environment treatments. Treatments were harvested when 20% to 25% of fruit on trees showed the visual indicators used commercially to indicate harvest maturity. Fruit were evaluated using attributes that determine quality and that may have implications for fruit post harvest behaviour. Temperature and crop load influences on time to maturity, fruit fresh and dry weight, fruit DM content, fruit firmness, fruit airspace content and estimated fruit cortical cell size will be presented and implications discussed.

**683**  
**Contributions of Early Season Environment and Crop Load to Apple Fruit Development**  
*C.J. Stanley\**<sup>1</sup> and *D.S. Tustin*<sup>2</sup>; The Horticulture and Food Research Institute of New Zealand Ltd., <sup>1</sup>Nelson Research Centre, PO Box 220, Motueka, New Zealand; <sup>2</sup>Hawkes Bay Research Centre, Private Bag 1401, Havelock North, New Zealand

Many factors contribute to final apple fruit size. Researchers have studied these factors and have developed models, some very complex. Results from many New Zealand regions over several years suggest that early season temperature along with crop load are the key factors driving final fruit size. Accumulated growing degree days from full bloom to 50 days after full bloom (DAFB), accounted for 90% of the variance in fruit weight of 'Royal Gala' apples at 50 DAFB under non-limiting low-crop-load conditions. In turn, fruit weight at 50 DAFB accounted for 90% of the variance in final fruit size at harvest under the low-crop-load conditions. We hypothesise that a potential maximum fruit size is set by 50 DAFB, determined by total fruit cell number, resulting from a temperature-responsive cell division phase. Under conditions of no limitations after the cell division phase, we suggest that all cells would expand to their optimum size to provide the maximum fruit size achievable for that cell number. Factors which affect growth partitioning among fruits, e.g., higher crop loads, would reduce final fruit size, for any given cell number, when grown in the same environment. In Oct. 1999, four different crop loads were established at full bloom on 'Royal Gala' trees (M9 rootstock) in four climatically different regions. In Hawkes Bay, similar crop loads were established at 50 DAFB on additional trees. Hourly temperatures were recorded over the season. Fruit size was measured at 50 DAFB and fruit will be harvested in Feb. 2000. These data should provide fresh insight and discussion into the respective roles of temperature and competition during the cell division fruit growth phase on apple fruit size.

**684**  
**Thinning and Crop Load Effects on Apple Fruit Growth**  
*Duane W. Greene\**; Dept. of Plant and Soil Sciences, Univ. of Massachusetts, Amherst, MA 01003

Chemical thinners can be classified as either blossom thinners or postbloom

thinners. Blossom thinners act by inhibit further pollination, pollen germination, or pollen tube growth. At petal fall it is not possible to distinguish between fruit that have been injured by blossom thinners, and those that will persist and continue to grow. The receptacles of blossom thinned fruit do not grow, whereas fruit that has not been treated and that also contain viable seeds, resumes growth within 4 to 6 days, depending upon temperature. Abscission of fruit treated with postbloom thinners does not usually occur until 1.5 to 3 weeks after application. Frequently, it is possible to identify fruit that will abscise and to make an initial assessment of thinning efficacy, within 4 to 6 days following application by measuring fruit growth rate. A reduction in fruit growth by as little as 15% to 20% less than rapidly growing fruit is usually sufficient to assume that the fruit will abscise sometime during the June drop period. The effects of specific chemical thinners on fruit growth and subsequent thinning will be discussed.

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## **88 WORKSHOP 12 (Abstr. 685) Junior Master Gardener Programs Tuesday, 25 July, 10:30 a.m.–12:30 p.m.**

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685

### **Junior Master Gardener Programs in Minnesota**

*Mary Hockenberry Meyer\**; Univ. of Minnesota, Minnesota Landscape Arboretum, 675 Arboretum Dr., Chanhassen, MN 55317

Development of a new children's horticulture curriculum, the Junior Master Gardener program, from Texas A&M Univ. has lead to several youth projects in Minnesota. In Chisago County, Minn., Master Gardeners have instructed 4-H leaders who taught weekly sessions to elementary age children. Older teens have been leaders in this project as well. In Hennepin County, Minn., the program has been used by teachers and Master Gardeners in a formal classroom setting. Additional programs in Anoka, Rice, Winona, and Washington Counties, Minn., have used this curriculum. Leaders say the strengths of the program are the extensive and detailed list of projects, the impact on the local community when children do the service component, and children's learning of the scientific concepts that are the basis of the program. Cost of the materials and distribution are negative features. Further program examples will be highlighted and detailed at this workshop.

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## **102 WORKSHOP 13 (Abstr. 686–687) Vegetable Cropping Systems Research: Techniques, Evaluation, and Application Tuesday, 25 July, 2:00–4:00 p.m.**

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686

### **Using an Agroecosystem Approach in Systems Research**

*Kathleen Delate\**; Dept. of Horticulture, Iowa State University, Ames, IA 50011

Because cropping systems must fit into the environmental, social, cultural and economic reality of the farming community, it is essential that practitioners are included in designing experimental techniques and evaluating application for their farms. Iowa State Univ. conducted a series of Focus Groups with growers and agribusiness professionals to assist in the design of vegetable cropping systems research trials. Trials were established to investigate vegetable agroecosystem status and needs. An agroecosystem analysis seeks to identify indicators of sustainability in a system, including plant health, biological diversity, soil/water quality, and level of biological control of insects and diseases. From this work, a checklist of ecological parameters has been developed for use in cropping systems research. Examples from Iowa, California, and North Carolina will be presented as case studies, exploring multi-disciplinary approaches to cropping systems research.

687

## **Implementation of Long-term Farming Systems Studies: Challenges and Opportunities**

*N.G. Creamer\** and *J.P. Mueller*; Dept. of Horticultural Science and Crop Science, North Carolina State Univ., Raleigh, NC 27695

The Center for Environmental Farming Systems (CEFS) is dedicated to developing farming systems that are environmentally, economically, and socially sustainable. Established in 1994 at the North Carolina Dept. of Agriculture Cherry Farm near Goldsboro, CEFS has >2000 acres (1000 cleared). This unique center is a partnership among North Carolina State Univ., North Carolina Agriculture and Technical State Univ., North Carolina Dep. of Agriculture and Consumer Services, non-governmental organizations, and other state and federal agencies, farmers, and citizens. Long-term cropping systems that integrate the broad range of factors involved in agricultural systems is the focus of the Cropping Systems Unit at CEFS. The USDA SARE program has provided funding to help establish a comprehensive long-term, large-scale experiment. Data collection and analyses include comprehensive soil and water quality, pests and predators (weeds, insects, and disease), crop factors (growth, yield, and quality), economic factors (viability, on/off farm impact, and community), and energy issues. Systems being compared are a successional ecosystem, plantation forestry/wood lot, integrated crop/animal production system, organic production system, and a cash-grain cropping system (BMP). An interdisciplinary team of scientists from almost every department from the College of Agriculture and Life Sciences, along with faculty from North Carolina Agriculture and Technical State Univ., NGO representatives, and farmers are collaborating in this endeavor. Challenges and opportunities in building collaborative teams and setting up such long-term trials will be discussed.

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## **142 WORKSHOP 19 (Abstr. 688–690) Opportunities and Challenges in the Development and Registration of Plant Growth Regulators Wednesday, 26 July, 10:00 a.m.–12:00 noon**

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688

### **New PGRs: High Risk Investment?**

*Wilhelm Rademacher\*<sup>1</sup>* and *Toni Bucc<sup>2</sup>*; <sup>1</sup>BASF Agricultural Center, 67114 Limburgerhof, Germany; <sup>2</sup>BASF Corporation, Agricultural Products Group, P.O. Box 13528, Research Triangle Park, NC 27709-3528

Plant growth regulators (PGRs) account for only a few percent of the worldwide sales of crop protectants. In recent years, most companies have drastically reduced their activities in the PGR area. The factors that have been of major relevance in this development are: a) Finding, developing and marketing a new PGR is more difficult and requires a considerably higher input as compared to other types of crop protectants, b) many segments of the market are fairly saturated with competitively priced products, and c) intensified legislation for the registration of new, and the re-registration of established products, has become a severe constraint, due to its absorbing large working and financial capacities. For these and other reasons, new types of PGRs will be economically viable only under certain circumstances, such as: a) A sufficiently large and profitable market guarantees a reasonable return on investment, b) costs for registration can be reduced by developing naturally occurring compounds, which may require considerably less toxicological and eco-toxicological studies, and c) PGR-like side activities of an existing herbicide, fungicide or insecticide can be exploited, which would, again, significantly reduce the costs for registration.

689

### **Field Research and Development of Plant Growth Regulators by the Agrochemical Industry**

*Craig A. Campbell\**; Abbott Laboratories, Inc., Orlando, FL 32818

The purpose of this presentation is to describe the general Field R&D process undertaken by Abbott Laboratories and other agrochemical companies when developing a new plant growth regulator (PGR). A recently registered PGR for citrus named 'EcoLyst' is used throughout the presentation as an example of common development strategies. Agrochemical companies acquire many new PGR com-

pounds from outside sources, while others are discovered internally. Internal technology is obviously much simpler to control. In Abbott's case, most of the new PGR compounds are brought in from other places as a result of focused efforts to find new technology for development. Researchers, sales and marketing personnel, and full-time acquisition specialists all share the responsibility for finding new prospect PGRs. After a new PGR is identified, a company like Abbott must first determine if the lead is potentially available, and then, if it has sufficient value to warrant acquisition or in-licensing efforts. Once a PGR passes an initial screening process and is approved for potential development, a coordinated chain of events is initiated throughout the company's organization to accelerate work on the project. Field R&D creates a comprehensive research plan for the PGR that contains development goals. The scope of the research program increases significantly after the first research year, provided results are favorable. University and government scientists are generally brought into the research programs after a year or two of in-house testing. At predetermined control points in the development process, go/no go decisions are made based on reviews of research data, business plans, and regulatory progress.

## 690

### Development of New PGRs from a University Perspective

Duane W. Greene\*; Dept. of Plant and Soil Sciences, Univ. of Massachusetts, Amherst, MA 01003

Plant growth regulators that are made available to University researchers usually come with an indication of biological activity, based upon in-house work by chemical companies. Often a practical use of the PGR is suggested. The PRG is applied at a range of concentrations at a timing that is appropriate to get the desired response. Undesirable side effects are noted. Follow up experiments are designed, usually altering concentration, time of application, or formulation, to maximize a response or to overcome and alleviate undesirable side effects. If the PGR is labeled, refinements for its use and grower recommendations are prepared. Critical in the development process is communication and interaction among researchers and industry personnel. This is exemplified by the exchange of ideas, sharing of data, and brain-storming that has occurred over the past 25 years at the Northeast Plant Growth Regulator Working Group meetings. Budget reductions and down sizing of programs at the University have forced researchers to depend more upon grant-in-aid support from companies. Several case studies will be presented to show the commercial development of some PGRs, including: Accel, cultar, Apogee, and ReTain. The evolving role of researches in the development of PGRs will be discussed.

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## 143 WORKSHOP 20 (Abstr. 691–693)

### Underpublicized, Underutilized, and Innovative Plant Tissue Culture Techniques Wednesday, 26 July, 10:00 a.m.–12:00 noon

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## 691

### Obtaining Shoot Explants From Softwood Shoots Forced From Large Stem Segments of Woody Plants

John E. Preece\*; Department of Plant, Soil and General Agriculture, Southern Illinois University, Carbondale, IL 62901-4415

Softwood shoots can be forced from sections of branches of trees or from basal stems of shrubs by cutting into ≈40-cm lengths and placing these segments horizontally in flats filled with perlite. We have had our best success using stems that are >1.5 cm in diameter. Although the best environment that we have found for producing the most and longest softwood shoots is under intermittent mist, this is unacceptable for producing explants because of microbial contamination. Rather, for micropropagation, watering must be done two to three times a day and care must be taken to avoid water spray onto the stem segments or the subsequent softwood growth. Irrigation can be by hand or by using drip irrigation. For trees, using the basal portions of large branches allows for selection of shoots from within the "cone of juvenility." Theoretically, these should propagate better than shoots taken from the outer, more adult portions. Although late winter through spring are the best times for forcing, some shoots will grow if the stem sections are harvested nearly any time of the year, except for October through December in southern Illinois.

## 692

### Plant Embryo Culture Techniques and Applications

Mark P. Bridgen\*; Dept. of Plant Science, Univ. of Connecticut, Storrs, CT 06269

Traditional and biotechnological breeding techniques are being united to develop exciting new plants and to improve existing cultivated plants by introducing natural variability from germplasm resources. Intervarietal, interspecific and intergeneric crosses can be accomplished by using plant embryo culture techniques, sometimes also referred to as embryo rescue. Embryo culture involves the isolation and growth of immature or mature zygotic embryos under sterile conditions on an aseptically nutrient medium with the goal of obtaining a viable plant. The technique depends on isolating the embryo without injury, formulating a suitable nutrient medium, and inducing continued embryogenic growth and seedling formation. The culture of immature embryos is used to rescue embryos from hybrid crosses that were once thought to be incompatible because they would normally abort or not undergo the progressive sequence of ontogeny. The culture of mature embryos from ripened seeds is used to eliminate seed germination inhibitors, to overcome dormancy restrictions, or to shorten the breeding cycle. New and exciting cultivars of *Alstroemeria*, also known as Lily-of-the-Incas, Inca Lily, or Peruvian Lily, have been bred by using zygotic embryo culture; these techniques and applications will be discussed.

## 693

### Practical Applications of Citrus Protoplast Technology

Jude W. Grosser\*; Oscar Olivares-Fuster, Geraldine H. Fleming, and Maria R. Albiach-Marti; Citrus Research and Education Center, University of Florida, 700 Experiment Station Road, Lake Alfred, FL 33850

Citrus protoplast technology has advanced to where several practical applications in variety improvement and plant pathology are routine. We will report on progress in the following areas: somaclonal variation—'Valencia' and 'Hamlin' sweet orange protoplasts have been selected for improved juice color, higher soluble solids, seedlessness, and altered maturity dates; somatic hybridization for scion improvement—allotetraploid breeding parents have been created from numerous combinations of elite parental material, and are now being used as pollen parents in interploidy crosses to produce seedless triploid varieties; somatic hybridization for rootstock improvement—numerous somatic hybrids combining complementary rootstock germplasm are under commercial evaluation and several look promising for wide adaptation, improved disease resistance, and tree size control; transformation—an alternative protoplast-based transformation that utilizes EGFP for selection has been developed; virus resistance assays—a protoplast-based assay is being used to screen varieties and candidate sequences for resistance to citrus tristeza virus at the cell level, saving time and greenhouse space.

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## 160 WORKSHOP 22 (Abstr. 694–695)

### How Future Usage on Minor Crops Is Likely to be Impacted by the Current Regulatory Process Wednesday, 26 July, 2:00–5:30 p.m.

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## 694

### Evaluation of Low-rate Herbicides for Minor Crops

Milton E. McGiffen, Jr.\*<sup>1</sup>, Steven A. Fennimore<sup>2</sup>, W. Thomas Lanini<sup>2</sup>, and Carl E. Bell<sup>3</sup>, <sup>1</sup>Department of Botany and Plant Sciences, University of California, Riverside, CA 92521-0124; <sup>2</sup>Department of Vegetable Crops, University of California, Davis, CA 95616; <sup>3</sup>University of California, Imperial County, Holtville, CA 92250.

The Food Quality Protection Act may result in the withdrawal from use of many herbicides in the "minor" crops: fruits, vegetables, herbs, flowers, and ornamentals. An obvious mitigation strategy is to test and register newer, low-rate herbicides that are currently used only in large-acreage field crops. The newer herbicides have low mammalian toxicity, few off-target effects, and are often used at rates of less than 0.1 kg/ha. Many of the older herbicides are applied at rates of several kg/ha and have off-target effects that can make their use problematic. Low-rate herbicides could replace the older chemicals commonly used in horticultural crops. We have tested several promising low-rate herbicides: carfentrazone, cloransulam, dimethenamid, halosulfuron, rimsulfuron, and sulfentrazone. Broccoli, cantaloupe, carrot, lettuce, onion, spinach, and processing tomato varieties

were screened for tolerance to low-rate herbicides at four locations in California that included desert, inland, and coastal environments. All of the crops tested had tolerance for one or more of the low-rate herbicides. Data on similar tests for other horticultural crops will also be presented. The potential for registering these herbicides in vegetables and other horticultural crops varies with the crop and the pesticide's manufacturer. Pesticides that may soon face removal from widespread use will be reviewed. Herbicides and other potential alternatives to currently registered herbicides will be examined to determine possible practical alternatives for specific crops and weeds.

695

### **Weed Control in Minor Crops After the Loss of Methyl Bromide**

*Chad Hutchinson\**; Univ. of Florida/IFAS, Hastings Research and Education Center, P.O. Box 728, Hastings, FL 32145-0728

The economics of pesticide production and registration has limited the number of pesticides registered for use in minor crops relative to agronomic crops. Current regulations such as the Food Quality Protection Act may further reduce the number of efficacious compounds registered for use on minor crops. Traditionally, the lack of registered pesticides for minor crops has been offset by soil fumigation. However, methyl bromide use is scheduled for phase-out in the United States by 2005, leaving a pest control vacuum in some crops. Loss of methyl bromide has stimulated research into the use of other soil fumigants for weed control. Methyl bromide, methyl iodide, propargyl bromide, 1,3-dichloropropene, and metham sodium have been tested alone and in combination with chloropicrin in laboratory experiments to determine their efficacy against *Cyperus esculentus* L. (yellow nutsedge) tubers. All the fumigants controlled nutsedge equal to or better than methyl bromide and resulted in synergistic control when combined with chloropicrin. Although excellent weed control can be achieved with all the fumigants in the laboratory, weed control in the field with the same fumigant may result in poor or no control. Further research is necessary to optimize the field application of the remaining fumigants to maximize pest control. In the near future, to achieve the broad-spectrum pest control obtained with methyl bromide, growers will need to rely on multiple control strategies. The most promising replacement program for broad-spectrum pest control includes dichloropropene/chloropicrin fumigation followed by a herbicide program or mechanical weed control. To control problem weeds that are not controlled with the in-season herbicide program, a chemical fallow program should be instituted in the off-season to reduce weed pressure during the cropping season.

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## **163 WORKSHOP 23 (Abstr. 696–697) Asian Horticultural Crops in North America Wednesday, 26 July, 4:00–6:30 p.m.**

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696

### **Asian Horticultural Crops and Human Dietetics**

*Usha Palaniswamy\**; School of Allied Health, U-101, Univ. of Connecticut, Storrs, CT 06269

Great mass of epidemiological evidence linking better health and lower risk of major diseases and chronic conditions such as heart disease and cancer to Asian dietary practices have stimulated interest in the Asian food crops. Another reason why Asian crops are gaining popularity is the dramatic growth in the Asian American population in North America, increasing more than 20% in the United States in the 1990s. The Asian populations are also increasing in diversity by the growing numbers of Indians, Thais, Vietnamese, and Cambodians, who are adding up to the more-established Asian Americans of Chinese, Japanese, and Korean origin. In addition to the diverse "fresh" vegetarian cuisine, the Asian medical systems that predominantly use herbs have fueled an interest in "foods used as medicine" and have acclaimed popularity among the general public.

697

### **Promotion and Marketing Strategies: Keep Them Coming Back For More**

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New foods have been introduced to the North American populations from many world cultures in both planned and unplanned situations. Success of such crops will depend on the acceptance of the consumers. Growers and retailers must educate customers about these new crops in order to ensure that the customer comes back for more. The different strategies that can be used successfully in the process of education, marketing, and promotion, including developing recipe cards, brochures, newspaper and magazine press releases, and talks and presentations to local and regional groups, will be discussed.