

tested, it accounted for 90% of an average sample. Impermeability, however, is not the only limiting factor to germination. Three disparate populations of seed, representing two different collection years have been investigated using moist pre-chilling, boiling water, leaching, gibberellic acid, hydrogen peroxide and mechanical and chemical scarification methods. Scarifying in concentrated sulfuric acid stimulates germination of some seed fractions and causes embryonic damage in others, suggesting variation in seed coat thickness. Similar results were obtained using a pressurized air-scarifier; the hard seed coat of some seed fractions were precisely scarified while others were physically damaged using the same psi/time treatment. Placing seed in boiling water increases germination from 4%, 7%, and 18% to 23%, 25%, and 77% in the three populations, respectively. Leaching for 24/48 h in cold (18 °C) aerated water or for 24 h in warm (40 °C) aerated water showed only a minor increase over the control. Pre-chilling at 5 °C for 30, 60, and 90 days showed no improvement over the control. Gibberellic acid-soaked blotters improved germination at 400 ppm to 20%, 10%, and 41%; at 500 ppm germination was reduced. Soaking seed for 24 h in a 3% concentration of hydrogen peroxide did not effect germination; at a 30% concentration germination was reduced. The considerable variation in seed dormancy expression may be a function of differences in environmental factors during development or seed age.

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Propagation of *Camptotheca acuminata*

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Research was undertaken to optimize seed storage and vegetative propagation of *Camptotheca acuminata*. *Camptotheca* is a member of the Nyssaceae native to southern China and is important because it contains the medicinal alkaloid camptothecin. Seeds stored in polyethylene bags in a refrigerator (4 °C) or freezer (-20 °C) maintained good germination (79% and 83%, respectively), while seeds stored at room temperature in open containers or polyethylene bags lost germination ability quickly (45% and 51%, respectively). Softwood cuttings of *Camptotheca* rooted readily in intermittent mist (4 s on every 6 min.) in coarse vermiculite when treated with K-IBA (indolebutyric acid, potassium salt) quick dips ranging from 1000 to 9000 ppm, with a 7000 ppm quick dip (5 s) promoting 82% rooting with little foliar damage. Actively growing shoot tip explants were tissue cultured on media containing Murashige and Skoog, Gamborg, and Woody Plant Medium (WPM) salts in factorial combinations with BA (benzyladenine). WPM containing 1.0 mg/IBA promoted excellent shoot proliferation; microcuttings were rooted, acclimated, and grown on in the greenhouse. *Camptotheca* is readily adaptable to modern nursery techniques for either seed or vegetative propagation.

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Effects of Jiffy Forestry Peat Pellets on Rooting and Subsequent Field Performance of Stem Cuttings of Loblolly Pine

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Experiments conducted in January (hardwood cuttings) and June (softwood cuttings) 1998 compared rooting and root dry weight (DW) of stem cuttings of three full-sib families of loblolly pine (*Pinus taeda* L.) rooted in Jiffy forestry peat pellets and Ray Leach Super Cells. Ray Leach Super Cells (vol. = 162 cm³) served as the control and contained a medium of 2 peat : 3 perlite (v/v). Pellet sizes used were 25-65, 30-65, 36-65, 36-75, 42-65, 42-80, and 50-95 (dry diam. - expanded height in mm). Cuttings were taken from hedged stock plants and rooted for 12 weeks under mist in a humidity-controlled greenhouse. Following evaluation for rooting in the June experiment, ≈500 rooted cuttings in pellets and Ray Leach Super Cells were field-planted in eastern Georgia in December 1998 to study the effect of pellet size and cutting development on first-year field growth. Rooting percentages in January for hardwood cuttings rooted in pellet sizes 42-80 (36%) and 50-95 (57%) were less than the control (83%). Root DW for each pellet size was less than the control. Rooting percentage in June for softwood cuttings rooted in pellet size 36-65 (77%) was greater than the control (64%) whereas rooting percentages for cuttings rooted in pellet sizes 42-80 (50%) and 50-95 (52%) were less than the control. Root DWs for cuttings in pellet sizes 25-65, 30-65, 36-65, and 42-65 were less than the control. Field performance data will be presented.

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Root-pruning Pin Oak Liners Affects Growth and Root Morphology

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Two experiments were conducted to test the effects of early root pruning on growth of pin oak (*Quercus palustris* Muenchh.). Experiment one tested the effect of radicle tip removal when radicles had reached 5, 10, or 15 cm below the substrate surface. Total root length was not affected by treatment, but root-pruned trees had more large-diameter lateral (primary lateral) roots than trees that were not root-pruned. The number of primary laterals increased if the radicle tip was removed at more shallow depths. Experiment two tested the effect of liner production in bottomless containers (roots air-pruned) of 5-, 10-, 15-, and 20-cm depths on subsequent growth in #2 (6-L) containers. Top and root growth was generally lowest in 5-cm-deep containers and highest in 10- or 15-cm-deep containers.

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Incorporation of Slow-release Fertilizer Accelerates Growth during Adventitious Rooting of *Artemisia*, *Gaura*, and *Nepeta*

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Accelerating growth of nursery stock can produce marketable plants in less time, thus potentially increasing profits. The primary objective of this study was to compare adventitious rooting and initial growth of cuttings of three perennials species in response to slow-release fertilizer incorporated into the propagation media. The experiment was a split-plot consisting of four blocks, nine nutrient treatments, three species, and four cuttings per replication within each block-nutrient, species treatment. Treatments consisted of Nutricote 13-13-13 Type 180 and Nutricote 18-6-8 Type 180 incorporated into the rooting media, each at 3, 6, 9, and 12 g·L⁻¹, and a control with no Nutricote. Species studied were *Artemisia ludoviciana* 'Valerie Finnis', *Gaura lindheimeri* 'Whirling Butterflies', and *Nepeta xfaassenii* 'Six Hills Giant'. There were of 144 cuttings per species for a total of 432 cuttings. Fertilizer treatments did not influence rooting percentage, and no significant differences were found between the two formulations of fertilizer for top growth, root growth, rooting percentage, or root number. However, regardless of formulation or rate, the eight fertilizer treatments resulted in greater top and root dry weights when compared to the control. Top and root dry weight increased linearly within both fertilizer formulations.

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Ex Vitro Rooting of Micropropagated *Hamamelis*

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Hamamelis cultivars are typically propagated by grafting onto *H. virginiana* rootstock. Grafting is labor-intensive and the understock frequently suckers which can lead to the loss of the scion. A cultivar growing on its own root system would eliminate this problem. Our research was undertaken to develop a successful method of rooting micropropagules. The source material was established cultures of *H. x intermedia* 'Diane', *H. virginiana*, and a *H. vernalis* selection. The rooting treatments consisted of four concentrations of K-IBA (0, 5, 10, and 20 μM) in 0.02% Tween 80. Three replicates of eight cuttings each were taken from the three sources for each of the four treatments. The cuttings were placed in 50-mL beakers, cut-end down, with 10 mL of the treatment solution. The beakers were sealed with Parafilm, and cuttings were soaked for 24 h. After treatment, the cuttings were randomly stuck into Kadon flats prepared in advance with a sterile mix of 1 peat : 1 perlite and were watered-in. Cuttings were misted, and flats were covered with plastic and Remay. They were kept in a warm (19–24 °C) greenhouse. Cuttings rooted in 3 to 4 weeks and were subsequently fertilized weekly with Peter's 20N–20P–20K at 150 ppm. At 12 weeks, data were collected for the rate of survival, height, branching, number of nodes, and root mass, and the plants were transplanted to quart pots. Ninety percent of the cuttings rooted; the most favorable response was with 10 μM K-IBA, although all treatments produced >80% rooting. This method was time and labor efficient. Moreover, micropropagation is not dependent on the season, and production of new plants could proceed on a continuous basis, making this a viable alternative to commercial grafting.

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Rooting of Softwood Cuttings from Dormant Woody Stems Forcing in a Forcing Solution Containing Silver Thiosulfate and Gibberellic Acid

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Research was conducted in Feb. 1999 to study the effects of including silver thiosulfate (STS), gibberellic acid (GA₃), or both in the forcing solution on rooting of softwood cuttings produced by forced dormant woody plant species. The cuttings were dipped for 10 s in 2000 ppm indole-3-acetic acid (IAA) or 2000 ppm indolebutyric acid (IBA). High percentages of rooting were observed in the two woody plant species examined. Root number and length of the new growth of *Cornus alba* and *Euonymus alatus* forced in a forcing solution containing the basic forcing solution treatment (8-HQC at 200 mg·L⁻¹ + 2% sucrose), the STS treatment, or the combination treatment of STS + GA₃ were not significantly different. However, treating the dormant stems of the two woody plant species examined in a forcing solution containing only GA₃ led to fewer and shorter roots when compared to all other treatments. Applying either IAA or IBA to the new softwood growth led to similar root length and number for both species. This forcing solution approach provides an attractive alternative for propagating woody plants during winter months.

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In Vitro Establishment and Growth of Bermudagrass, Buffalograss, Saltgrass, and Zoysiagrass

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There are turfgrasses species that are clonally propagated: notably bermudagrass, buffalograss, and zoysiagrass. Some of the early cultivars of these species are no longer widely grown, and may eventually be lost if not preserved. In order to facilitate studies on the long-term cryopreservation of these species and specific lines of saltgrass, it is necessary to develop suitable micropropagation procedures. We have developed protocol for the isolation and establishment of clean cultures in vitro for all four species. A 1/2-strength MS basal medium with Nitsch & Nitsch vitamins, 5 mg/L of thiamine, 2 mg/L of glycine, 30 g of sucrose, 7 g of agar with varying growth regulators has been used. Explant materials are prewashed in the greenhouse prior to a 15- to 30-min soapy wash in the laboratory. After a 30- to 60-min rinse in running water, nodal sections are surface-disinfested in 10% bleach with Tween 20 for 15 min, followed by three sterile water rinses. This procedure, sometimes with PPM (a proprietary antimicrobial compound), results in 50% or greater clean cultures. Rapidly growing nodal sections work best and preferably those not established in soil. We have tested various growth regulator combinations and have found that 10 mg/L of BA results in proliferation of buffalograss and saltgrass. However, proliferation remains relatively slow, requiring 8 to 12 weeks to develop sufficiently for subculture. Although we have succeeded in obtaining clean cultures of bermudagrass and zoysiagrass, proliferation is minimal. Further research is ongoing to develop a proliferative system with these two species.

95 POSTER SESSION 13 (Abstr. 349–367)

Nutrition

Tuesday, 25 July, 1:00–2:00 p.m.

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Determining Nitrogen Requirements of Lettuce through Presidedress Soil Nitrate Testing (PSNT)

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High rates of N fertilization of cool-season vegetables has contributed to NO₃-N pollution of groundwater in the Salinas Valley of central California. Ten field demonstrations were conducted in 1999 to document the utility of presidedress soil NO₃-N testing in maximizing N fertilizer efficiency in iceberg lettuce (*Lactuca sativa* L.). In each demonstration, a plot 36 beds wide x the entire field length was established in a commercial lettuce field. The cooperating growers applied 1 to 3 N sidedressings in these fields. Before each sidedressing the soil NO₃-N con-

centration in the top 30 cm of the plot was determined by an on-farm quick test technique. If NO₃-N was >20 mg·kg⁻¹, no N was applied at that sidedressing; for NO₃-N <20 mg·kg⁻¹, ≈4 kg N/ha was applied for each milligram per kilogram below the 20 mg·kg⁻¹ threshold. Plot yields, harvested by commercial crews, were compared to the yield of adjacent areas of the field that received the growers' full sidedress N regime. Across fields, seasonal sidedress N application in the PSNT plots averaged N only at 86 kg·ha⁻¹, almost 60% less than the average N (212 kg·ha⁻¹) applied by the growers. Yields in the PSNT plots averaged 1824 boxes/ha, compared with 1829 boxes/ha in the companion field plots. Whole leaf N concentration at heading was above published sufficiency standards in all PSNT plots. Evaluation of heads after 10 days of storage at 5 °C showed that sidedress N application rate did not affect visual quality, decay, or midrib discoloration. We conclude that PSNT can reliably be used to minimize wasteful sidedress N applications in lettuce.

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Response of Dominican Oregano (*Lippia micromera* Schan.) to Nitrogen, Phosphorus, and Potassium Fertilization

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Dominican oregano is a traditional seasoning leaf in Caribbean cuisine. However, little information is available regarding its mineral nutrition when grown as a commercial crop. Field studies were conducted to determine the short-term response of recently transplanted Dominican oregano to N, P, and K in a clay soil. Dominican oregano plants 15 to 20 cm tall were used. A randomized complete-block design with 13 treatments and three replications was utilized. Treatments were 0 fertilization (control) and 20, 40, 60, and 80 kg/ha of N, P₂O₅, or K₂O applied 20 days after transplanting. Experimental units consisted of 12 plants at with a distancing of 1.0 x 1.0 m. Above-ground biomass accumulation was determined 3 months after treatment. Analysis of variance and regression analysis was performed on the resulting data. Biomass accumulation in Dominican oregano was significantly influenced by N, P, and K fertilization rates. Crop yield increased linearly as nutrient rates increased. Nitrogen fertilization had a stronger influence on Dominican oregano biomass accumulation than P and K fertilization. Results indicate that fertilizing Dominican oregano increases its biomass yield. However, due to its seasoning nature, the effect of mineral fertilization on the essential oils of this crop must be analyzed.

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Nitrogen-fixing Water Fern Azolla as Biofertilizer for Hot Pepper (*Capsicum chinense* var. Scotch Bonnet)

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Scotch Bonnet pepper is a valuable commodity for Jamaica and the Caribbean, both for local consumption and for export because of its unique flavor and pungency. It is a valuable cash crop for small farmers who supply most of the fruit needed for processing and export. Azolla is a small water fern that grows on the surface of water bodies or on moist soil. Due to the presence of the nitrogen-fixing cyanobacterium *Anabaena azollae*, it fixes molecular nitrogen. This fern is used as biofertilizer for rice in millions of hectares in Asia. In the present work, experiments were carried out to determine the suitability and usefulness of both fresh and dried Azolla as biofertilizer for Scotch Bonnet pepper. A control without any fertilizer and a fertilizer control with 100 kg N/ha, supplied as ammonium sulfate, were used in 2-m² plots, with three replicates for each treatment. Fertilizer was supplied in three split doses. Fresh Azolla was spread at the base of each plant and the soil was kept moist for the duration of the study. Dry Azolla was spread like a mulch around the base of the plant and used as a split treatment similar to inorganic fertilizer. Both the fresh and dry Azolla increased the marketable fruit yield over the control without fertilizer. Dry Azolla resulted in a similar yield as the fertilizer treatment [80%] while the fresh Azolla had a 60% increase in the yield over the control. In addition, dry Azolla resulted in early anthesis by 3 days over the fertilizer control. The dry weights of the whole shoot also showed increases similar to fruit yield. The dry Azolla also helped to improve the soil conditions and retained moisture for long periods. The results suggest that dry Azolla can be successfully substituted for chemical fertilizer for pepper. The cost of preparing Azolla to be used as fertilizer is calculated to be about 10% to 15% of the cost of chemical fertilizer for small farmers.

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Using Winter Cover Crops For Seedless Watermelon Production

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Cover crops offer an excellent source of nutritional requirements for production of vegetables in sustainable agricultural system. By using this concept, field experiments were conducted in 1998 at three locations in Virginia; Petersburg, James City, and King and William County, and five cover crop treatments; Hairy Vetch (HV), Crimson Clover (CC), HV+Rye, CC+Rye, and a conventional bare-ground control were used for their potential support of nutritional requirements for production of a seedless watermelon crop. The results indicated that the yield levels of seedless watermelon following cover crop treatments had significantly higher number of fruits per acre and the crimson clover treatment had higher fruit size in one of the sites (King William County) as compared to the other four treatments and two sites suggesting that cover crop/crops alone have the potential to support nutritional requirements for seedless watermelon to sustain production, thus becoming a viable and profitable alternative to using inorganic nitrogen source. The effects of cover crops on chemical composition of seedless watermelon were generally not significant. The results also indicated that watermelons produced using sustainable crop production methods are comparable to those produced using conventional methods. Our studies support using seedless watermelon as a viable alternative and high-value cash crop for Virginia farmers' especially tobacco growers, other small-scale producers, and limited resource farmers.

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Organic Nutrient Management of Greenhouse Production of Edible Flowers in Containers

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Eight species of edible flowers were grown in 12.5-cm (1.5-L) square containers during the months of November through May, in a root medium suitable for organic certification or a standard peat and perlite mixture with preplant fertilizer. Plants were fertilized with 200 mL of either a water-soluble fertilizer (19–1.8–19) at 300 ppm N, fish emulsion (5–0.4–0.8), or a certified organic, commercially available soluble fertilizer (6–2.6–5), each at 300 or 600 ppm N applied every 2 weeks. Shoot fresh and dry weights were measured and percent dry weight was calculated. The fresh weights for all species were highest for plants fertilized with the organic fertilizers. For all but one species the organic fertilizer treatments had the same or higher dry weights than the inorganic control. The percent dry weights for all species were the same or higher for the inorganic control treatment. The effect of the organic fertilizer rate on the dry weight was species-dependent. The highest flower production generally occurred with 300 ppm N. Flower size was measured for *Viola tricolor* and *Viola x. wittrockiana* species. For both species flower size was smallest for plants fertilized with the 600 ppm certified organic fertilizer. Root media pH and EC were tested at 6-week intervals throughout the experiment. In general, the pH increased from the first to the second sampling date, but only increased or decreased slightly for later dates, and there was little effect of fertilizer type. Root media EC decreased initially with minimal change later.

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Influence of Foliar Application of Calcium Nitrate on Carrot Root Tissue Electrolyte Leakage and Storage Characteristics

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The influence of calcium nitrate fertilization on the storage characteristics of carrot (*Daucus carota*) roots was investigated. Plants of 'Navajo' carrots grown under irrigation were sprayed with a 2% solution of $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ at a rate of 50 kg/ha Ca 10 days before harvest. Quality of carrot roots stored at 5 °C was evaluated monthly for sweetness, tissue electrolyte leakage, disease development and visual characteristics. For disease development, the crown portion of the carrot roots was inoculated with an ascospore solution (2×10^9 spores/mL) of white mold (*Sclerotinia sclerotiorum*) before storage. When determined after 1 month of storage, percent tissue electrolyte leakage in the Ca-treated carrots decreased 52% as compared to that obtained from the control. Sugar contents of the cortex and xylem tissues were not affected by calcium nitrate fertilization. Changes in

other quality parameters of carrot roots for an extended storage period, including white mold development, will be presented. Initial findings of this research suggest that foliar calcium feeding at the final stage of plant growth may enhance the quality of carrot roots during storage.

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Effect of Season on Nitrate Accumulation in Hydroponic Lettuce

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Serial plantings of hydroponic lettuce were grown throughout the year in the northeast United States to determine how sunlight intensity and solution nitrate affect nitrate in leaf tissue. Two nutrient solutions were used. All essential elements were supplied at the same concentration, except nitric acid was added to the high-N treatment to increase nitrate to 5.7 mM (352 ppm), compared to 4.0 mM (248 ppm) in the low-N treatment. A feedback control system maintained a constant conductivity and volume in the recirculating nutrient solution. The actual nitrate concentration in solution was higher in winter than in summer. In winter, it rose to 800 ppm in the high-N solution, while it remained below 200 ppm in the low-N solution. In summer, nitrate was 200 to 400 ppm in the high-N solution, compared to 40 to 120 ppm in the low-N solution. Concentration of other mineral elements remained at levels similar to the original formulation. Nitrate concentration in leaf tissue when the lettuce plants reached a marketable size was sensitive to sunlight and nitrate supply. In spring and summer, tissue nitrate was as low as 1100 ppm. It increased to about 4000 ppm in lettuce grown in mid-winter in a shaded greenhouse and fed high-N solution, while low-N plants had less than 3000 ppm nitrate. Tissue nitrate was related to solution nitrate. Tissue nitrate increased in proportion to solution nitrate, up to about 400 ppm nitrate in solution, then leveled off at a concentration of about 4000 ppm in the leaves, a relation that was the same under all sunlight intensities. The accumulation of nitrate in the nutrient solution was one cause of the high concentration of nitrate in lettuce leaves.

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Composition of Leafy Greens as Affected by Season and Conventional or Organic Fertilization

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Leaf tissue composition may depend on season and method of fertilization. Lettuce and spinach were grown in spring, fall, and winter in unheated high tunnels using organic or conventional fertilization. The root medium was either perlite fertilized with a nitrate-based complete soluble fertilizer, or leaf compost/perlite 1:1 v/v fertilized with cottonseed meal. Growth rate did not differ due to the method of fertilization, but specific leaf area was 10% greater with compost. Growth in compost raised the concentrations of total reduced nitrogen, phosphate, and potassium in both species. Effects of season were factored with a 3rd-order polynomial in Julian day. Nitrate, total phosphorus and potassium varied with season. Interaction of effects of season and fertilization were only significant for total reduced nitrogen and phosphate in leaves of lettuce. The difference in nitrogen due to fertilization was larger in fall harvests than at other times of year. There was a similar, but nonsignificant, trend with time for total reduced nitrogen in spinach. Differences in nitrate due to fertilization were small, compared to those of reduced nitrogen. The same seasonal trend in potassium was seen in both species, and for both methods of fertilization. Concentrations were highest in spring and lowest in fall.

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Nutraceutical Roles of Polyphenolic Compounds from Berry Fruits

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Polyphenolic compounds (particularly anthocyanins, proanthocyanidins, and other flavonoids) from some fruits and vegetables have significant and diverse impacts on human health preservation. While it's well recognized that some of the polyphenolics in foods we consume have a protective and proactive role against disease, very little has been known about how they accomplish this feat. A range of bioassays (in vitro and in laboratory animals) were adapted to examine compounds extracted from berry fruits, and separated into distinct fractions by vacuum chromatography. The proanthocyanidin class of compounds, as well as mixtures of proanthocyanidins and other flavonoids, were significantly bioactive against

both the promotion and initiation stages of chemically-induced carcinogenesis. Potent antioxidant activity was not confined to particular fractions, but was present in several classes of compounds. Identification and characterization of the bioflavonoids is complicated both by apparent interactions between related compounds that occur together within horticultural fruits, and interferences from some substances (pectins and complex sugars) that depress observed response in bioactivity assays.

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Nitrogen Fertilization and Lychee Flowering and Production in Southern Florida

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Despite the increasing popularity in American markets of the fruit of the illustrious lychee (*Litchi chinensis* Sonn.), unreliable flowering and yield has had serious impacts on lychee growers in southern Florida. Lychee flowering is normally induced by chilling temperatures. Unpredictable weather, high rainfall, and excessive nutrients cause unreliable flowering in southern Florida. Although growers have no control over the weather, they need to be able to manage the growth, vigor, and reproduction of trees through practices that optimize flowering. When excessively watered and fertilized, lychee trees grow vigorously with frequent vegetative flushes every 2 to 3 months. The lack of maturity of these late vegetative flushes prevents flower stimulation from mild temperatures in January and February, when flowering typically occurs on trees that have not experienced vegetative flushes in the late fall or early winter. Thus, by adopting nitrogen fertilizer management practice, growers should be able to induce abundant flowering even in mild winters. Our preliminary results demonstrated that timing and rates of applications of nitrogen fertilizer significantly affected concentrations of soil and leaf N. High nitrogen levels in the leaves induced more vegetative flushes and less flowering, and consequently less fruit yield.

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Irrigation Rate and Nitrogen Concentration Affect Plant Growth and Leaf Senescence of Citrus Rootstock Seedlings

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The interactive effects of irrigation rate and nitrogen concentration of the irrigation water on the growth of seedlings of two citrus rootstocks were studied. Four-month old seedlings of Swingle citrumelo [*Citrus paradisi* Macf. x *Poncirus trifoliata* (L.) Raf.] and Volkamer lemon (*C. volkameriana* Ten. & Pasq.) were grown for ≈10 months in square citripots filled with a Candler fine sand. Plants were irrigated at 0.5, 0.75 or 1.0 times the evapotranspiration rate. Irrigation was applied using water containing 0, 7, 21, or 63 ppm nitrogen. Plant growth increased with irrigation rate and nitrogen concentration. Evapotranspiration rates, as determined from weight losses of reference plants, increased with nitrogen rate. Overall plant growth and weekly evaporation rates were greater with Volkamer than with Swingle. Leaf senescence of Swingle was more pronounced at low irrigation rates and/or low nitrogen concentrations than it was with Volkamer. Increasing nitrogen concentration of the irrigation water during the winter months reduced leaf senescence of both Swingle and Volkamer seedlings, and also promoted continuous growth in Volkamer. Leaf growth of Swingle ceased during the winter months, regardless of the nitrogen concentration of the irrigation water.

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The Relationship of Mineral Nutrients in the Rhizoplane, Rhizosphere, and Bulk Soil during the Growth of Apple Rootstock Seedlings

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Malus hupehensis Rehd apple rootstock seedlings and the rhizobox technique were used in this study. The seeds were collected from healthy mature trees at the Wanshougong Forest Farm in Shandong, China, stratified at 0 to 2 °C for 60 days, sown into growing medium with 1/3 loam soil+1/3 silt sand+1/3 compost manure, grown until the three-leaf stage, and then transplanted into rhizoboxes with four plants in each box. The rhizoboxes were inserted into the ground with the top of the boxes levelled with the soil surface. After the root mattress formed in the center of the box, plants were harvested by carefully dividing each box into

rhizoplane, rhizosphere, and bulk soil, and mineral nutrients in each part were analyzed. The relationships were tested between the rhizoplane, rhizosphere, and bulk soil for each nutrient. Significant correlations were found for NH₄⁺, NO₃⁻, K, Mg, Zn, and Cu in the rhizoplane, rhizosphere, and bulk soil. There were significant relationships for P and Ca between the rhizoplane and rhizosphere, but not between the rhizoplane or rhizosphere and bulk soil. Fe in the rhizoplane closely related to Fe in the rhizosphere but not to Fe in bulk soil. No correlation was found between the rhizoplane and either rhizosphere or bulk soil, but close correlation existed between rhizosphere and bulk soil for Mn.

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Effects of Fertilizer Rates on Fruit Quality of 'White Marsh' Grapefruit in a Sandy Soil

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Fertilization is among the most important factors influencing fruit quality of citrus. Effects of individual element such as N, P, or K on fruit quality have been well-documented. Much less has been done on the interactions of N, P, and K in relation to citrus fruit quality. A field experiment was conducted from 1994 to 1999 in a commercial grove on a Riviera fine sand (Loamy, siliceous, hyperthermic Arenic Glossoaqualf) to investigate the effects of fertilizer rates and sources on fruit quality of 26-year-old 'White Marsh' grapefruit trees (*Citrus paradisi* Macfad.) on Sour Orange rootstock (*Citrus aurantium* Lush). Fertilizer was applied as water-soluble dry granular broadcast (three applications/year) at N rates of 0, 56, 112, 168, 224, and 336 kg/ha per year using a N:P:K blend (1.0:0.17:1.0). There was a quadratic relationship between fruit weight or peel thickness and fertilizer rates. Fruit weight per piece increased with fertilizer rates from 0 to 168 kg N/ha per year, but decreased from 168 to 336 kg N/ha per year. Fruit size was small at zero or low fertilizer rates due to nutrient deficiencies. Large fruit sizes of 'White Marsh' grapefruit in the sandy soil were achieved at fertilizer rate around 168 kg N/ha per year. Increasing fertilizer application rates higher than 168 kg/ha per year greatly increased the number of fruit per tree, but decreased the size of fruit. Peel thickness, which is related to the fruit size, declines at higher fertilizer rates. Increase in fertilizer rate from 0 to 336 kg N/ha per year increased solids content and fruit acid concentration of the grapefruit. Fertilization rate effect on fruit Brix concentration was more complicated. Brix concentration was not affected by increasing fertilizer rates from 0 to 168 kg N/ha-per year, but was increased at higher fertilization rates (168 to 336 kg N/ha per year). As a result, the Brix/acid ratio was, in general, decreased by increasing fertilizer rates.

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Balanced Nutrient Management in Citrus Grown in Acid Red Soils of Southeast China

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Citrus is a major fruit crop in the acid red soils (Ultisol) of hilly areas in Southeast China. These soils are normally deficient in P, K, and other elements. Integrated nutrient management is important for sustainable production of citrus in these areas. In this study, a systematic approach was used to identify the limiting factors for plant growth, using sorghum as a test species. Long-term field experiments were conducted with seven different P and K supply levels to determine optimal application rates for citrus (cv. Ponkan), following alleviation of other limiting factors. The primary nutritional limitations to plant growth in red acid soils included: severe deficiencies in N, P, and K, and moderate deficiencies in Ca, Zn, and B. With increasing application of P and K to field soil, N concentrations in citrus leaves decreased up to 60% due to dilution from increased growth, whereas P and K concentrations increased 2-3 fold. After 2 years of fertilizer application, the N: P: K ratio in leaves reached 1:0.5:1 for the optimal P and K treatment. The available P and K in the soils, measured after harvest each year, increased with increasing P and K application rates. However, within each treatment, increase in P and K with additional years of fertilization was modest. Citrus fruit yields generally increased with increasing P and K and reached a maximum at P and K rates of 125 kg P₂O₅/ha and 500 kg K₂O/ha. In 3 years of successive field experiments, the highest net income was obtained by a balanced NPK fertilization practice using N : P₂O₅ : K₂O input of 450 : 125 : 500 kg/ha per year.

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Near-infrared Reflectance Spectroscopy for the Determination of Total Nitrogen, Amino Acid, and Nonstructural Carbohydrates in Apple and Almond Samples

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Near-infrared (NIR) reflectance spectroscopy was used to determine the chemical composition of fruit and nut trees. Potted almond and bench-grafted Fuji/M26 trees were fertigated during the growing season with different N levels by modifying the Hoagland to create different levels of nitrogen and carbohydrates in plant tissues during dormancy. Dried, ground, and sieved shoot, shank, and root samples were uniformly packed into NIR cells and scanned with a Foss NIRSystem 6500 monochromator from 400 to 2500 nm. Statistical and multiple linear regression methods were used to derive a standard error of performance and the correlation between NIR reading and standard chemical composition analysis (anthrone, Kjeldahl and Ninhydrin methods for carbohydrate, total N, and amino acid analysis, respectively) were determined. The multiple determination coefficients (R^2) of apple and almond tissues were 0.9949 and 0.9842 for total nitrogen, 0.9971 and 0.9802 for amino acid, and 0.8889 and 0.8687 for nonstructural carbohydrate, respectively.

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Studies on the Effects of Nitrogen Source on Pecan Nutrient Uptake and Plant Growth and Development

Tehyung Kim*, Harry A. Mills, and Hazel Y. Wetzstein; Department of Horticulture, Univ. of Georgia, Athens, GA 30605

As a plant nutrient, nitrogen is the element in highest demand in terms of quantity and makes up about 2% to 3% of plant dry matter. In this study, we evaluated the effect of nitrogen source on plant growth and nutrient uptake in pecan (*Carya illinoensis*). Seedlings were hydroponically grown under three nitrogen nutrient regimes where the ratio of nitrate : ammonium was varied, i.e., 3:1, 1:1, and 1:3. High ammonium nutrition had an inhibiting effect on seedling growth. Plants grown under 1:3 (nitrate : ammonium) exhibited significantly lower biomass, decreased root/shoot ratio, and lower specific leaf weight than other treatments. Total nitrogen uptake on a dry weight basis was highest in the high ammonium treatment. In the equal molar treatment (1:1 nitrate : ammonium), plants exhibited preferential uptake of ammonium-form nitrogen. Ammonium-form nitrogen is generally used in pecan orchard practice. Our data suggest that further studies evaluating the effects of nitrogen source are warranted to determine if similar detrimental effects on pecan growth occur in the field. Such studies would be useful for optimizing current fertilization practices.

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Seasonal Fluctuations in Nutrients and Resorption Efficiencies of Different Pecan Genotypes

Tehyung Kim* and Hazel Y. Wetzstein; Department of Horticulture, Univ. of Georgia, Athens, GA 30605

It has been shown that perennial woody plants exhibit marked seasonal changes in nutrient content, carbon metabolism, and organ development. A knowledge of seasonal nutrient allocation and temporal accumulation patterns can be useful in the development of fertilization regimes that reflect the biology of a tree crop. Maintenance of optimum leaf nutrient status is an important priority in pecan cultural practice. However, a systematic evaluation of nutrient resorption is lacking in pecan. In this work, seasonal changes in nutrients and carbohydrates were evaluated in pecan trees grown under orchard conditions. In addition, resorption efficiencies of eight pecan cultivars were evaluated. Significant levels of resorption were observed in all essential elements, but cultivar differences were not significant. Seasonal patterns of nutrient and carbohydrate content in leaf, stem, and shoot tissue, will be presented as well as a structural evaluation of abscission zone formation.

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Nitrogen Fertigation of Young Navel Orange Trees

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Citrus production in the southwestern U.S. is highly dependent on inputs of irrigation and N fertilizer to achieve optimum fruit yield and quality. Microsprinkler

irrigation may allow for substantial increase in efficiency of N and water application. However, best management practices have not yet been developed for microsprinkler use, particularly on newly established citrus trees. Experiments were conducted during 1997–98 in central Arizona to evaluate the effects of various N rates and fertigation frequencies on growth and N partitioning in young 'Newhall' navel oranges planted in Apr. 1997. Two experiments were conducted, each with factorial combinations of N rate and fertigation frequency. In one experiment, non-labeled N fertilizer was used and in the other ¹⁵N-labeled N fertilizer. Trunk diameter, leaf N, and ¹⁵N partitioning in the trees were measured. During 1997, neither trunk diameter or leaf N were affected by N rate or fertigation frequency. No more than 6% of the N applied was taken up by the trees, and about 50% of the fertilizer N taken up was found in the leaves. Trees grew much more rapidly in 1998. Leaf N in fertilized plots was significantly higher than in control plots, but leaf N in all trees remained above the critical level of 2.5%. Despite rapid tree growth during 1998, no more than 25% of the fertilizer N applied was taken up by the trees. About 60% of the fertilizer N taken up was found in the leaves. Results suggest that N applications are not needed during the first growing season after planting for microsprinkler-irrigated citrus trees in the Southwest. Only modest rates (68 to 136 g/tree) will be needed during the second season to maintain adequate tree reserves.

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Scavenging Capacity of Active Oxygen Species in Blackberry

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The effect of blackberries (*Rubus* sp.) genotypes on antioxidant activities against superoxide radicals (O_2^-), hydrogen peroxide (H_2O_2), hydroxyl radicals (OH), and singlet oxygen (O_2), was evaluated. The results were expressed as percent inhibition of active oxygen species production in the presence of fruit juice. The active oxygen radical absorbance capacity (ORAC) value referred to the net protection in the presence of fruit juice, and was expressed as micromoles of α -tocopherol, ascorbate, α -tocopherol, and β -carotene equivalents per 10 g of fresh weight for O_2^- , H_2O_2 , OH, and O_2 , respectively. Among the different cultivars, juice of Hull' blackberry had the highest oxygen species, superoxide radicals (O_2^-), hydrogen peroxide (H_2O_2), hydroxyl radicals (OH), and singlet oxygen (O_2) scavenging capacity. Different antioxidants have their functional scavenging capacity against active oxygen species. There were interesting and marked differences among the different antioxidants in their abilities to inhibit the different active oxygen species. β -carotene had by far the highest scavenging activity against O_2^- but had absolutely no effect on H_2O_2 . Ascorbic acid was the best at inhibiting H_2O_2 free radical activity. For OH, there was a wide range of scavenging capacities with α -tocopherol the highest and ascorbic acid the lowest. Glutathione had higher O_2^- scavenging capacity compared to the other antioxidants.

152 POSTER SESSION 21 (Abstr. 368–380)

Nutrition

Wednesday, 26 July, 1:00–2:00 p.m.

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Effects of Nitrogen Fertilization on Saw Palmetto (*Serenoa repens*)

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Saw palmetto (*Serenoa repens*), a palm species native to the Southeastern United States, is used in ornamental plantings and landscaping. From Mar. 1998 to Mar. 1999, we conducted an experiment to assess effects of different levels of nitrogen addition on three sizes of containerized saw palmettos in southwest Florida. Palmettos were in 26-L containers (plant height 30 to 50 cm, no above-ground rhizome), 38-L containers (plant height 50 to 80 cm, above-ground, prostrate rhizome), and 170-L containers (three erect above-ground rhizomes 1 to 2 m high). We applied granulated ammonium nitrate (34% N) to the soil surface four times during the year, at 6 yearly rates of N addition for each size category of palmettos (24 palmettos in each size category). We also applied granulated con-

centrated triple superphosphate (46% P₂O₅) and potassium chloride (60% K₂O) at constant yearly rates for each size category. We measured height and width of plants and length and width of leaves at the beginning and end of the experiment. We quantified leaf N, P and K concentration two days after first fertilizer application, and at the end of the experiment. For 26-L plants, increasing rates of N addition were reflected in higher levels of leaf N concentration two days after the first application. Leaf growth was less, and leaf K concentration at the end of the experiment was lower with increasing rates of N addition. Leaf P concentration at the end of the experiment decreased, and then increased with increasing rates of N addition. Plant growth for 170-L plants decreased and then increased, and leaf P concentration at the end of the experiment decreased with increasing rates of N addition.

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Influence of Temperature and Product on Nutrient Release Patterns of Three Polymer-coated Fertilizers

Chad E. Husby, Alex X. Niemiera*, Robert D. Wright, and J. Roger Harris; Department of Horticulture, Virginia Tech, Blacksburg, VA 24061

Use of polymer-coated fertilizers (PCFs) is widespread in the nursery and greenhouse industries. Temperature is the main factor affecting nutrient release from PCFs, yet there are few reports that quantify temperature-induced nutrient release. Since container substrate temperatures can be at least 40 °C during the summer, this research quantified the release of fertilizer salts in the diurnal container substrate temperature range of 20 to 40 °C. Three PCFs (Osmocote Plus 15-9-11, Polyon 18-6-12, and Nutricote 18-6-8) were placed in water-filled beakers at 40 °C until one-third (Expt. 1) or two-thirds (Expt. 2) of Osmocote's N was released. For Expts. 1 and 2, each fertilizer was put into sand-filled columns and leached with distilled water concurrent with column temperature incrementally increasing from 20 to 40 °C and then to 20 °C over a 20-h period. Leachate fractions were collected at every 2 °C increase and analyzed for fertilizer salts. In Expt. 1 and in the range of 22 to 30 °C, salt release was highest, lowest, and intermediate for Nutricote, Osmocote, and Polyon, respectively. In the range of 38 to 40 °C, release was highest, lowest, and intermediate for Osmocote, Nutricote, and Polyon, respectively. In Expt. 2, salt release in the range of 22 to 30 °C was the same as in Expt. 1. However, at 38 to 40 °C, release was highest, lowest, and intermediate for Polyon, Nutricote, and Osmocote, respectively. Results show that salt release for PCFs are dependent on the temperature x fertilizer age interaction.

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Iron and Iron Compounds Reduce Phosphorus Leaching from Nursery Containers

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Phosphorus contamination of surface water is a growing problem associated with container production of nursery plants. Iron and iron compounds have the ability to adsorb phosphorus and render it immobile. Incorporating iron compounds into media at the base of nursery containers serves to filter out phosphorus from fertilizers while still allowing the plant to collect enough phosphorus to grow. Two experiments were devised. The first experiment examined how much phosphorus various iron compounds would adsorb. Metallic iron adsorbed the most phosphorus, followed by HCl reacted magnetite (a form of iron ore), Fe₂O₃, Fe₃O₄ and magnetite. In the second experiment, PVC tubes (4 cm inner diam.) were filled to a level of 5 cm with a phosphorus adsorbing layer containing growing media that was 25% or 50% by weight iron compounds. Compounds included metallic iron, HCl reacted magnetite and magnetite. Plain media was used as a control. A layer of 15 cm of media and slow-release fertilizer was applied above the adsorptive layer. One hundred milliliters of distilled water was applied to PVC tubes daily to simulate irrigation. Metallic iron reduced phosphorus leachate to almost 0 for over 2 weeks. HCl reacted magnetite was also effective in reducing phosphorus leachate. Magnetite only affected phosphorus leachate slightly.

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Influence of Inorganic and Organically Based Fertilizers on Plant Growth and Nutrient Leaching

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Selected fertilizer treatments were applied to vinca (*Catharanthus roseus* 'Pep-permint Cooler') in the landscape to determine their effect on growth and nutrient

leaching. In plots 0.9 m x 2.3 m, inorganic fertilizers were applied as either a single application of 4.9 g N/m² pre-plant, or a split application with 4.9 g N/m² applied pre-plant followed by application of 2.45 g N/m² at 8 and 12 weeks after planting (WAP). Inorganic fertilizers included 15N-0P-12.6K granular fertilizer, Osmocote 14N-6.0P-11.6K, and Osmocote 17N-3.0P-10.1K controlled-release fertilizers. Three different organically based fertilizers were applied pre-plant and were composed of recycled newspaper amended with animal manures (chicken, beef cattle, or dairy) and adjusted with (NH₄)₂SO₄ to achieve C:N ratios of either 20:1 or 30:1. A standard industry treatment of 13N-5.6P-10.9K (4.9 g N/m²) incorporated pre-plant and 17N-3.0P-10.1K (4.9 g N/m²) topdressed post-plant was also included. Leachates, collected with lysimeters, from inorganic fertilizer plots had lower levels of total N (NO₃⁻ + NH₄⁺) compared to organically based fertilizer plots through 8 WAP. Of the inorganic fertilizer plots, those receiving 15N-0P-12.6K granular fertilizer had higher total N levels at 1, 2, and 4 WAP than other inorganic fertilizer plots. Total N in leachates declined over the study and by 12 WAP were similar among all treatments. Vinca treated with organically based fertilizers (C:N 20:1) had the highest foliar color ratings through 8 WAP; however, color ratings declined thereafter and by 16 WAP had the lowest ratings. Plants treated with organically based fertilizers had greater shoot dry weights 20 WAP and larger growth indices 8 and 20 WAP.

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Nitrogen and Phosphorus Release from Controlled-release Fertilizers while Overwintering Nursery Stock under Plastic

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Nutrient release patterns from several different controlled-release fertilizers (CRF) were studied during the overwintering period of a long-term nutrient uptake, leaching, and loss study of Azalea (*Rhododendron*) cv. 'Karen' and Holly (*Ilex cornuta*) cv. 'China Girl', under sprinkler and drip irrigation. In Maryland, diurnal winter temperatures can vary from ≈10 °C to above 15 °C. Most growers, therefore, cover frames with opaque plastic for cold protection from November through April. This is also the period when many growers apply CRFs on those plant species that take more than 1 year to produce. Few data are presently available on the release patterns of CRFs under variable temperature conditions in late winter/early spring. We hypothesized that substrate temperatures warmer than 15–16 °C will result in CRFs releasing nutrients at a time when root systems are inactive, with a major loss of nutrients with the first few irrigations in Spring. This 105-day study quantified nitrogen (N) and phosphorus release patterns from four brands of CRF (Osmocote, Nutricote, Scotts High N, and Polyon) with 270- and 360-day release rates, under these conditions. Each CRF was top dressed onto blocks of 18-month-old holly or azalea (n = 112) in 11.5-L (3-gal) containers, at a (low) rate of 6.1 g N per container. Ten randomly selected pots from each treatment were sampled every 15 days using two sequential leachings of distilled water, for a target leaching fraction of 25%. Leachates were recovered and analyzed for nitrate and orthophosphate concentrations. Ambient canopy temperatures were recorded continuously with remote temperature (HoBo) sensors from which degree days above 15–16 °C were calculated and correlated with CRF release patterns.

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Response of Dwarf Yaupon Holly to Fertilizer Rate and Duration

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Multiple branched liners of *Ilex vomitoria* Ait. 'Nana' were greenhouse-grown in 3-L containers with a 2 pine bark : 1 Canadian peat : 1 sand substrate. Plants were fertilized weekly with a solution of 50 N, 10 P, and 30 K (mg·L⁻¹) for either 5, 10, or 15 weeks. Then plants for each of the three fertilizer durations were fertilized weekly with a solution of either 50, 150 or 300 N, 10 P, and 30 K (mg·L⁻¹) for an additional 15 weeks, at which time root and shoot dry weights were determined. A control group of plants was fertilized weekly with 300 N (mg·L⁻¹) for 30 weeks. Shoot dry weight increased linearly as fertilizer rate or duration of fertilization increased. Root dry weights increased linearly as fertilizer duration increased while root dry weights were not different due to fertilizer rate. These data indicate that duration of fertilization is important in promoting root and shoot growth; however, the largest amount of root and shoot dry weight resulted from the highest N application rate (300 mg·L⁻¹) for the longest duration (30 weeks).

Interactions of Temperature and Fertilizer Concentration Affect Growth of Petunia and Geranium

Jong-Goo Kang¹ and Marc van Ierse², ¹Sunchon National Univ. South Korea; ²Univ. of Georgia, Dept. of Horticulture, Univ. of Georgia, 1109 Experiment St., Griffin, GA 30223

Fertilizer recommendations for fertilizing bedding plants are normally based on nitrogen content of the fertilizer solution. However, nutrient availability is more closely related to the concentration of nutrients in the growing medium than the concentration in the fertilizer solution. Environmental conditions can affect the accumulation of nutrients in the growing medium and optimal fertilizer concentrations are likely to depend on environmental conditions. To test this hypothesis, we grew petunias and geraniums under three temperature regimes (35 °C/27C, 25 °C/17C, and 15 °C/7 °C) and with five concentrations of fertilizers [electrical conductivity (EC) of 0.15, 1, 2, 3, and 4 dS·m⁻¹]. Temperature and fertilizer EC affected the plant growth. Optimal fertilizer EC decreased as temperature increased. Growth was better correlated with EC of the growing medium than with EC of the fertilizer solution. Irrespective of growing temperature, plant growth was best when EC of the growing medium was between 3 and 4 dS·m⁻¹. A lower growing medium EC slowed down growth, presumably because of mild nutrient deficiencies. Higher fertilizer concentrations in the growing medium (>4 dS·m⁻¹) decreased growth because of salt stress. The EC of the growing medium increased with increasing EC of the fertilizer solution and with increasing temperature. Because of the interactive effect of fertilizer concentration and temperature on the EC of the growing medium, plants should be grown with more dilute fertilizer solutions at higher temperatures. Fertilization guidelines for growers should be based on maintaining the EC of the growing medium within an optimal range instead of the more traditional recommendations based on the concentration of the fertilizer solution.

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Low Phosphorus Controls Bedding Plant Growth

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'Ultra Red' petunia (*Petunia xhybrida* Hort. Vilm.-Andr.), 'Bonanza Orange' marigold (*Tagetes patula* L.), and 'Marglobe' tomato (*Lycopersicon esculentum* Mill.) were fertilized with a low-P, water-soluble fertilizer to evaluate the potential of low-P nutrition to control growth. Beginning at transplanting, plants received N at 150 mg·L⁻¹ fertilizer solutions twice a week until finish from 20N-4.3P-16.6K continuously (control), 20N-0P-16.6K continuously, or four or six applications of 20N-0P-16.6K followed by 20N-4.3P-16.6K to finish. Growth media were two commercial soilless substrates (Fafard 3B and Metro Mix 360), and a 2 sphagnum peat moss : 1 perlite : 1 vermiculite combination (v/v) containing no starter or granular P fertilizer. All species in the 2:1:1 growth medium responded to low P treatments with significant growth reductions. In the commercial media, presumably due to the presence of a P-containing starter fertilizer, there were no visible effects of low P on the size of ornamental species and only small reductions in the measured growth characteristics compared to the control. Tomato growth, however, was significantly reduced by low P treatments in both commercial media. This research suggests that the P requirement of some ornamental bedding species is very low and that to use low P for growth control, plants must be grown in a substrate containing no P fertilizer. Under these conditions, four or six applications of 20N-0P-16.6K followed by 20N-4.3P-16.6K to finish resulted in desirable growth reductions and no P deficiency symptoms.

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Relationship of Bract Boron Content and Boron Application to Bracts Necrosis of Poinsettia

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One factor in the development of poinsettia (*Euphorbia pulcherrima* Willd. ex Klotzch) bract necrosis is plant nutrition. Twenty poinsettia cultivars were grown as 15-cm single-pinned plants in Metro mix 510 with standard commercial practices for irrigating, fertilizing, and pest control. Seventy days after initial anthesis, plants were harvested and the number of necrotic and healthy bracts recorded. Mineral nutrients in bract margins were determined. The only nutrient that had a significant relationship to incidence of bract necrosis across the 20 cultivars was bract B content ($R^2=49.5\%$, $P < 0.001$). This suggests that cultivars with lower bract B content are more susceptible to bract necrosis. Using 'Supjibi' plants

grown in the Metro mix 510, we applied topical sprays of B (0, 4, or 8 mM) weekly during bract development or once at initial anthesis (8 mM). Also a weekly drench treatment of B (10 mM) was applied initially at bract color change and continued for 2 more weeks. By 42 days after initial anthesis, all B treatments averaged together reduced incidence of bract necrosis from 33.1% for controls to 10% for plant receiving B treatment. The B drench treatment resulted in leaf scorching and there was some leaf tipburn with the 4 and 8 mM B weekly sprays. The single spray (8 mM B) treatment at initial anthesis caused no injury. Although B sprays are not a replacement for Ca sprays as a control for bract necrosis, the results suggest a role for B in the etiology of bract necrosis.

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Differential Response of Two Poinsettia Cultivars to Calcium Stress for Postharvest Disorders

Bernard Bible^{*} and Richard McAvoy; Department of Plant Science, University of Connecticut, Storrs, CT 06269-4067

Poinsettia (*Euphorbia pulcherrima* Willd. ex Klotzch) bracts are susceptible to postharvest disorders like the pathogen *Botrytis cinerea* and the abiotic disorder bract necrosis that degrade plant appearance. 'Freedom Red' and 'Supjibi' poinsettias were grown hydroponically with Ca concentrations of 0.5 or 4 mM. Forty days after initial anthesis, plants were harvested and their bracts subdivided into true-bracts and transitional-bracts for determination of incidence of botrytis lesions and bract necrosis. Mineral nutrients in bract margins were determined only for true-bracts. Margin Ca concentrations were relatively high in true bracts only for 'Supjibi' plants exposed to 4 mM Ca solutions. Botrytis incidence was increased for transitional-bracts but not true-bracts for both cultivars by plant exposure to low (0.5 mM) Ca solutions compared to control (4 mM Ca) plants. The smaller the poinsettia roots relative to shoots, the higher the incidence of botrytis for 'Freedom Red' transitional-bracts and 'Supjibi' true-bracts. Botrytis incidence was higher on transitional-bracts (13%) than on true-bracts (3.5%) for both cultivars exposed to low Ca, whereas the incidence of bract necrosis on 'Supjibi' was the same on true-bracts and transitional-bracts in either Ca solution. Bract necrosis was not evident on 'Freedom Red' plants in either the 0.5 or 4-mMm Ca solutions, however for 'Supjibi' exposure to low Ca solutions increased incidence of bract necrosis from 5.5% for controls to 19.3%. The effect of Ca stress applied to poinsettia roots was genotype dependant for bract necrosis but not for botrytis.

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Calcium-Boron Regimes Effect Incidence of Postharvest Disorders on Poinsettia Bracts

Bernard Bible^{*} and Richard McAvoy; Department of Plant Science, University of Connecticut, Storrs, CT 06269-4067

Incidences of poinsettia (*Euphorbia pulcherrima* Willd. ex Klotzch) bract disorders like the pathogen *Botrytis cinerea* and the abiotic disorder bract necrosis are related to nutrient stress. 'Supjibi' poinsettias were grown hydroponically with four Ca-B combinations of 0 or 4 mM Ca added with either 5 or 120 μmol B added. Forty-one days after initial anthesis, plants were harvested and their bracts subdivided into true-bracts and transitional-bracts for determination of incidence of botrytis lesions and bract necrosis. Mineral nutrients in bract margins were determined for leaves, transitional-bracts and true-bracts. Leaf margins had the highest concentrations of Ca and B. Margins of transitional-bracts had substantially lower concentrations and margins of true-bracts the least. The low Ca (0 mM) or low B (5 μmol) treatments greatly reduced the concentrations of these elements, respectively, in all three tissue types. The low Ca-low B treatment increased the incidence of bract necrosis on true-bracts from 1.9% on controls (4 mM Ca, 120 μmol B) to 27%. Low Ca treatment increased bract necrosis on transitional-bracts from 1.6% on controls to 24.3%. Bract necrosis incidence was the same on true-bracts and transitional-bracts, whereas the incidence of botrytis was higher on transitional-bracts than on true-bracts. Botrytis incidence was increased for true-bracts and transitional-bracts by plant exposure to low Ca solutions compared to plants in 4 mM Ca. Low Ca reduced growth in roots, but not shoots. Ca and B stress to roots increased the incidence of bract necrosis on true-bracts, while only Ca stress increased incidence of botrytis.

Substrate and Nutrient Variations for Optimization of Commercial Cultivation of *Anthurium andreaeanum* var. Honduras

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The Production of the cut flowers of *Anthurium andreaeanum* was in decline after Hurricane Gilbert in 1988 and the subsequent wide-spread problem of bacterial blight in Jamaica and the Caribbean. New methods of cultivation and new varieties were necessary for the development of the industry. In addition, with the destruction of coconut trees, the supply of commonly used coconut husk became difficult. The present work has focused on the development of alternative media to coconut husk and on the development of cultural and fertilizer practices that increase plant productivity and reduce incidence of disease. The variety Honduras was chosen for the study. A 3 x 3 latin square design was used to evaluate four media—coconut husk, brick chips, gravel, and basalt igneous rock—two methods of cultivation—pots and beds; at three levels of fertilizer—244, 448 and 896 kg N/ha per year. While the coconut husk was still the better medium, the other media have resulted only in about 15% decline in the marketable blooms. This was offset by the requirement for low maintenance and lower fertilizer rates in inorganic media compared to coconut husk. Pot culture proved to be better for management purposes as well as production for the same area of production, as density of the plants could be increased and the incidence of disease could be easily managed. These results will be discussed with emphasis on a simple cost-benefit analysis of various combinations of cultivation methods and practices for commercial cultivation of *A. andreaeanum* var. Honduras in the Caribbean.

380 Differential Responses of Container-grown Ornamental Foliage Plants to Silicon Application

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Silicon (Si) is the second most-abundant element in soils, and its concentration in soil solution ranges from 0.1 to 0.6 mM, which is the same concentration range as some of the major nutrient elements such as calcium, magnesium, phosphorus, and sulfur. Increasing evidence has recently suggested that Si plays important roles in improving plant growth. However, little information is available on Si effects on container-grown ornamental plants, particularly since most are grown in soilless media where Si sources are greatly limited. The objectives of this research were to evaluate Si absorption and translocation in diverse container-grown ornamental plants and to determine whether Si absorption could improve plant growth. Liners from 39 plant species were potted in peat and pine bark-based soilless media and grown in a shaded greenhouse. Plants were fertigated with a Peter's 24-8-16 water-soluble fertilizer containing 0, 50, and 100 mg·L⁻¹ of Si. Once marketable sizes were reached, plants were harvested and fresh and dry weights determined; Si and other nutrient elements in roots and shoots were measured. Results indicated that 32 of the 39 evaluated species were able to absorb Si, with large quantities further transported to shoots. Of the 32 Si-responsive species, 17 showed significant dry weight increases, whereas the other 15 only exhibited Si absorption and translocation with no apparent growth responses. The seven non-responsive plant species showed no significant increases in neither Si absorption and translocation, nor dry weight.

44 POSTER SESSION 7 (Abstr. 381–397) Extension/Technology Transfer/Public Education Monday, 24 July, 1:00–2:00 p.m.

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Food Safety Starts on the Farm: A Comprehensive Food Safety Curriculum for Fruit and Vegetable Extension Agents

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The 1998 Fresh Trends Survey, conducted by "The Packer," indicated that about 60% of consumers are more concerned today, than 1 year ago, about Salmonella, *E. coli* O157:H7, and other bacteria on fresh produce. Since 1987, the number of produce-associated outbreaks has doubled, affecting twice as many people, and involving a variety of fruits and vegetables. Three quarters of these outbreaks (75%) were associated with domestically grown produce. In recent months, as several large grocery chains have informed their produce suppliers that growers must have a certified plan for the farm that focuses on reducing risks for microbial contamination, to continue supplying fruits and vegetables. These actions have caused extreme concern among fruit and vegetable producers. A comprehensive educational curriculum has been developed for growers and shippers focused on recommended "Good Agricultural Practices." This effort is the result of an extensive collaborative project, involving researchers, extension educators, and grower organizations nationwide. The curriculum sections include the history of foodborne illness associated with produce, the basic principles of food microbiology, recommended good agricultural practices to reduce risks of contamination due to irrigation water, wild and domestic animals, manure, and farm workers hygiene, resources for training employees, farm assessment worksheets, and other information resources. These educational materials and visuals will be made available on CD-ROM in the near future.

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The Southwest Ohio Fruit and Vegetable School—A Successful Multi-county Program

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Southwest Ohio Fruit and Vegetable School is a regional training program for both commercial growers and amateur gardeners. The program has been sponsored by four county Extension offices in Southwest Ohio and has attracted a total attendance of 571 since 1995. We have offered two concurrent sessions, one for commercial fruit and vegetable growers, and one for amateur gardeners. This combination has proven to be the key factor in the success of the program. Attendees are allowed to move between the commercial and amateur sessions. Many commercial growers brought their spouses along since there were good topics for both of them. Backyard gardeners benefitted from the commercial session since the information was very applicable to their situation. Commercial growers also receive their pesticide recertification credits. Some of the popular topics for the commercial session included: management of diseases, insects, and weeds of fruits and vegetables; production of fresh market tomatoes, green beans, peppers, sweet corn, and pumpkins; production of herbs and specialty crops; production of apples, raspberries, strawberries, and blueberries. Popular topics for the non-commercial session included: growing tree fruits and small fruits in home gardens; raised bed gardening; growing giant pumpkins; nuisance wildlife damage control; growing and using culinary herbs; beneficial insects; and managing garden pests without using conventional insecticides. The Southwest Ohio Fruit and Vegetable School has been a very successful training program and could serve as a good model for other county Extension educators.

Landscape Professionals Learn Environmental Practices through the FYN/CLIP Program

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The Florida Yards & Neighborhoods Program (FYN) provides special educational and outreach activities directed at the community to help Floridians reduce pollution and enhance their environment by improving landscape management. The Commercial Landscape Industry Professionals program (CLIP) was developed to provide training in FYN principles to Florida's landscape professionals. CLIP was pilot-tested from 1997 to 1999 in the six-county Indian River Lagoon area of coastal east-central Florida. Teaching resources, audiovisuals, teaching outlines, and reference materials were developed to create an FYN/CLIP curriculum, which was delivered to landscape maintenance personnel through a series of training programs. In addition, the pilot program developed marketing approaches, incentives, and recognition programs for landscape professionals to encourage their participation in CLIP training programs. Evaluations of training programs and results of pre- and post-test questionnaires demonstrate the effectiveness of the FYN/CLIP program.

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PLANT: Purdue Landscape and Nursery Thesaurus—An Internet Database for Commercial Landscape Horticulture

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Information on the Internet relative to the landscape and nursery industries is rapidly expanding. However, finding reliable sites on subjects of interest to the field of commercial landscape horticulture is a difficult task. PLANT: Purdue Landscape and Nursery Thesaurus, is an extensive database of links to Internet information for professional landscape contractors/managers and nursery growers in Midwest and Northeast states. PLANT currently consists of 21 independent pages on topics from "Computer Software" to "Winter Hardiness", with >2500 links to appropriate Internet information. A search mode allows one to search the database by key words as well. This extension-based tool is also an excellent resource for class assignments in the area of ornamentals and landscape horticulture. As a work in process, PLANT is regularly updated and expanded to provide multiple sources if Internet information on topics of interest to the landscape and nursery industries. PLANT can be found at bluestem.hort.purdue.edu/plant/.

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Survey of Technical Information Requirements for Hispanic Nursery Employees

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At least 90% or more of the Oregon nursery industry workforce is composed of Hispanic employees who understand little English, with Spanish their primary language. Currently, most of the technical information available to the nursery industry is in English. A Spanish translation of the OSU/ODA Nursery Newsletter to Hispanic workers began in Aug. 1999. The first newsletter contained a questionnaire to determine the foremost technical topic interests. Surveys were also conducted at the Spanish sessions at the Ornamentals Northwest Seminars and of 40 Hispanic employees during visits to five Oregon nurseries. In total, 340 surveys were conducted with 158 respondents. At the Ornamental Northwest seminars, 57% of those attending the Spanish sessions answered the survey. Eighty-seven percent replied that insect control information was their leading technical information interest, 81% disease and 80% weeds. Other interests were nutrition at 73% and propagation and plant identification, both at 67%. Twenty-one percent of newsletter readers responded to the questionnaire. Like the seminar respondents, newsletter readers indicated pest control information was very important to them; however, 91% found all the information presented of value and 97% wanted to continue to receive future issues. This finding was consistent with responses from nursery visits where respondents indicated their delight to receive technical information in Spanish.

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Employment Trends Within the Illinois Horticultural Industry

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Horticulture crops are a multi-million dollar industry in Illinois, providing employment opportunities as well as strengthening many local economies. To help establish a "green-goods" industry basis for Illinois, ≈300 surveys were mailed to members of the Illinois Nurserymen's Association, including owners and operation managers of retail and wholesale nurseries, greenhouses and garden centers. The focus of the questionnaire was on the horticultural products and services provided and the value of these sales and services to residents of Illinois. Questions were included regarding the pool of available labor, the total number of industry employees, including full and part-time employees, and the starting and average salaries for employees. A 25% response rate was achieved with 76 surveys returned and analyzed. Results examined fundamental predictors in gaining industry employment such as education and experience, employee demographics and average compensation for those employed at various levels. Provided that survey responses were indicative of the overall Illinois horticulture industry, responses provided evidence that the horticulture industry contributes approximately \$67 million in salary and wages to the Illinois economy. While universities are reporting an increase in the number of female horticulture graduates, respondents indicated that 74.8% of their employees were male. Businesses reported an average of 28 employees including sales and office staff. However, very few businesses had hired people with disabilities or were aware of the services the state can provide to businesses hiring people with disabilities. Businesses employed an average of 2.5 managers with an approximate annual salary of \$48,000, and an average of 15 laborers with an approximate annual salary of \$21,000. Correlations provided insight into which areas of the industry hired persons with horticulture degrees and the types of experience most valued by the industry.

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A Website for Evaluating Postproduction Quality of Parade™ Roses

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Postproduction evaluation trials have been developed in North America and Europe to test postproduction performance of potted roses from individual growers. The results of the trials have been compiled on the "Roses On The Web" Website (www.parade.dk). Roses on the WEB is a cooperative project between Poulsen Roses ApS, Denmark, the Danish Institute of Agricultural Sciences, and the Univ. of Florida. The goal of the Website is to provide growers participating in the evaluation trials a quick and easy way to obtain results on the postproduction quality of their roses. Plants receive 4 days of simulated transport, sleeved in a box in darkness at 16 °C. After transport, plants are maintained at 20 °C at 8 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ for 12 hours/daily. Relative humidity is maintained at 55% ± 5%. To determine quality, several parameters are recorded at day 0 (day of arrival), 11, 18, 22, and 28. The recordings include the number of open and damaged flowers and buds, percentage of damaged leaves, and the presence of disease and pests. Based on the results of all the measurements, each plant is given a postproduction rating or index, indicating quality. Results from each trial are tabulated and stored on the Website. Growers are able to view their results by entering a password. Growers can evaluate their quality over time and are also able to compare their quality with other growers. Many quality problems are manifested in the postproduction environment and can often be directly related to incorrect greenhouse conditions and/or cultural practices. "Roses On The Web" is a tool that provides quick, up-to-date information that can be crucial to the success of a grower. Differences in quality were found based on grower, time of year and variety.

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Extension Water Quality Training for the Nursery Industry

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A comprehensive educational program focusing on water quality protection was developed for the Oklahoma nursery industry. The program focused on best management practices to limit pesticides and nutrients in irrigation runoff and on capture and recycle technology as a pollution prevention strategy. Key profes-

sionals from the departments of entomology and plant pathology, biosystems and agricultural engineering, and horticulture formed a multidisciplinary team within the Oklahoma Cooperative Extension Service (OCES). During 1998, water quality workshops were conducted on-site throughout Oklahoma at leading nursery operations. These workshops were designed to highlight best management practices (BMPs) that were already in place as a foundation on which to implement additional BMPs with the assistance of the OCES team. Training workshops were augmented by written publications, by web-based information, and by videotape instruction. These provided for ongoing education beyond the formal grant period. The written materials included a water quality handbook for nurseries and a fact sheet on capturing and recycling irrigation runoff. The water quality handbook was also made available on the web and a website on disease management for nurseries using recycling irrigation was provided. The water quality video, highlighting successful growers, was designed to show aspects of both best management practices and capture and recycle technology. Results of these 3-year extension efforts will be discussed.

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Evaluation of Activators for Composting

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Activators are suggested as adjuvants to accelerate rates of composting of plant residues. Three activators, two microbial preparations and one enzyme-based material, were assessed. The feedstock for composting was a 1:1 volumetric ratio of vegetative food wastes and autumn leaves from broadleaf trees. Composting was conducted in 0.35-m³, covered, plastic bins. In one experiment, the bins were filled to capacity twice, once at treatment initiation and at 1 week later. Treatments included no activator, an addition of each microbial preparation individually, addition of the enzyme-based activator individually, and additions of one of the microbial preparations and the enzyme-based activator in combination. The individual applications were at full-strength according to recommendations on the labels, and the combinations were at full-strength or at half-strength according to the recommendations. Piles in the bins were turned weekly, and activators were added weekly or only once according to the manufacturers' recommendations. Composting proceeded for 60 days. In a second experiment, the same protocols were followed with the modification that feedstock was added to each bin weekly for 60 days, followed by a 30-day curing period. Temperatures of the compost were recorded weekly. Piles were moistened weekly after turning. None of the activators accelerated the rate of composting relative to the rate with no activators. Rate of composting was evaluated by comparison of the weekly temperatures of the piles, the volume of compost produced, and the texture of the compost. Tomato (*Lycopersicon esculentum* Mill.) plants grew equally well in composts from each of the treatments. The conclusion was that compost activators did not modify the process or quality of compost produced from food and tree-leaf residues.

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Feasibility of Solar-powered Irrigation for Remote Areas

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Remote areas of the United States and developing nations depend on either electric grid extension or diesel power for operating crop irrigation systems. However, electric grid extension is expensive and often impractical. Diesel pumps are expensive, polluting, and require maintenance to operate. Utilizing the energy of the sun, captured by photovoltaic panels, to power irrigation systems offers a cost-effective, pollution-free, and maintenance-free alternative. Solar-powered pumping systems are capable of delivering water from rivers or wells in volumes up to 2000 gal/min. Combining solar power with drip irrigation takes advantage of the natural coincidence of peak energy from the sun and the crop's peak need for water. In 1999, cabbage was grown comparing solar and conventionally powered drip irrigation systems at the Rutgers Univ. Snyder Research and Extension Farm, Pittstown, N.J. The solar system was operated by a 1.5-horsepower motor powered by 18 solar modules.

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C-factor Research on Horticultural Crops for Erosion Prediction: Philosophy and Methodology of Data Collection

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Even though research and education systems have transformed agriculture from a traditional to a high-technology sector, soil erosion still remains as a major universal problem to agricultural productivity. The Universal Soil Loss Equation (USLE) and its replacement, the Revised Universal Soil Loss Equation (RUSLE) are the most widely used of all soil erosion prediction models. Of the five factors in RUSLE, the cover and management (C) factor is the most important one from the standpoint of conservation planning because land use changes meant to reduce erosion are represented here. Even though the RUSLE is based on the USLE, this modern erosion prediction model is highly improved and updated. Alcorn State Univ. entered into a cooperative agreement with the NRCS of the USDA in 1988 to conduct C-factor research on vegetable and fruit crops. The main objective of this research is to collect plant growth and residue data that are used to populated databases needed to develop C-factors in RUSLE, and used in databases for other erosion prediction and natural resource models. The enormous data collected on leaf area index (LAI), canopy cover, lower and upper biomass, rate of residue decomposition, C:N ratio of samples of residues and destructive harvest and other growth parameters of canopy and rhizosphere made the project the largest data bank on horticultural crops. The philosophy and methodology of data collection will be presented.

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Barriers and Incentives for Consumers' Adoption of Landscape Practices Recommended by the "Florida Yards and Neighborhoods" Extension Program

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A random sample was made from 2000 Extension customers who had attended programs on Environmental Landscape Management within 17 counties in Florida. Four-hundred Master Gardeners and 500 other citizens were sent a questionnaire that gathered information on demographics as well as six landscape practices. Incentives and barriers to practice adoption were also examined. The return rate of the questionnaires was 83%. Results of the analysis and their implication for Extension programming will be presented.

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The University of Kentucky Home Landscape IPM Program

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A home landscape integrated pest management (IPM) extension program has been initiated in the Univ. of Kentucky College of Agriculture. In order for this program to be effective, activities must integrate aspects of general landscape management with pest management. The main tenets of the project encompass four areas: making wise choices when selecting plants for the landscape; practicing proper planting and transplanting techniques; maintaining the health of the plant in the landscape using proper watering, fertilizing, and pruning techniques; and practicing an integrated approach to managing pests in the landscape. Outreach mechanisms for this project include the preparation and broadcast of radio scripts, the production of educational videos for use by county agents, print material, and addition of a home landscape IPM section to the Univ. of Kentucky IPM web page. Examples of these activities will be presented. The initial emphasis of the program is on woody landscape plants; however, other areas of landscape management, including annuals and perennials, turf, and home fruit and vegetables, will be added as time and funding allow. This outreach program may be the first exposure many people have to IPM principles and thus it will play an important role in educating the public to integrated pest management practices that are a vital part of modern agriculture production.

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WITHDRAWN

Rock Gardening in Oklahoma

*D. Steve Owens**, *Michael A. Schnelle*, and *John M. Dole*, Department of Horticulture and Landscape Architecture, Oklahoma State University, Stillwater, OK 74078

Rock garden plants, typically alpine in nature, are indigenous to higher elevations and thus perform poorly in the South. Consequently, they are not adapted to environments with tight clay soils, extreme heat, high humidity, and periodic drought. A video and extension circular were produced to demonstrate the construction, planting and maintenance of an appealing yet durable rock garden for Oklahoma. Modifications in soil type, plant materials, and arrangement of rock, wherein small micro-habitats are created, comprise the core of the project. The aforementioned educational materials benefit the gardening public with previously unavailable information for Oklahoma. The video is included in the Oklahoma State Univ. Cooperative Extension Service video library, where it is available via rental or purchase. It provides informative visual instruction, complementing the written publication that outlines stepwise construction techniques coupled with a list of adaptable plants. Both the publication and video may have applications for gardeners in peripheral states.

396**Children's Gardens in Which to Learn and Grow—A Service/Learning Project**

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The purpose of a service/learning project is two-fold: to gain skill in one's area of study and simultaneously to provide service to an unrelated community. This project provided such an educational opportunity for our Horticulture and Landscape Architecture students by providing the mechanism for them to develop and practice their skills of garden design, presentation, installation, and maintenance, while also providing a service to Oklahoma's fifth grade teachers and their students. Through their service, our students gained insight into the creation of public gardens, specifically ones for children. This project created a template through which elementary educators could then work with their communities to develop children's gardens at their schools. Our students presented gardening ideas via slides to fifth grade classes, geographically distributed throughout Oklahoma, and then surveyed them for their input into a garden designed for and by children. The survey accessed the needs and dreams of both the fifth grade students and their teachers. The children's and teachers' desires, as expressed in the surveys, were incorporated into garden designs by our students. A prototype of one of the children's gardens was then installed at the Oklahoma Gardening studio grounds with the help of Horticulture and Landscape Architecture students, OBGA Ambassadors (a group of horticulturally trained volunteers from the Greater Stillwater Community), and Oklahoma elementary school teachers, who sought to gain experience in garden installation in order to create a children's garden at their own schools. The processes, from conception through design and installation, and finally utilization for elementary education, were videotaped and incorporated into a "how-to" video and fact sheet, produced and made available through the Oklahoma Cooperative Extension Service (OCES).

397**Assessment of Community Tree Planting Project Reveals Social and Psychological Benefits**

*Christopher Catanzaro** and *Enefiok Ekanem*; Cooperative Agricultural Research Program, Tennessee State University, Nashville, TN 37209

A community tree planting project was conducted on the border of an urban Nashville, Tenn., neighborhood in Autumn 1994. In Jan. 2000, a written survey was developed to assess residents' perception of this site. Responses were gathered voluntarily and anonymously following a community meeting. Photographs of the site taken before the planting and again recently were available to respondents. Descriptions of the site's appearance prior to planting (turf only) included barren, boring, and lacking character. Comments regarding the site with trees suggest that trees provide cover and shade, are aesthetically pleasing, and represent positive human involvement. The average rating of the site's appearance prior to planting was "fair," while its recent appearance was rated "very good." Among three tree species included in the planting, Southern magnolia was strongly preferred over Canadian (Eastern) hemlock and Eastern redbud. Respondents valued magnolia's size, unique flowers and leaves, and evergreen nature. Most

respondents did not use the area for any specific purpose. Despite that fact, respondents stated that they benefitted from the soothing aesthetics of the landscaped site, and that the site added value to the neighborhood and implied the qualities of belonging and leadership. An unintended outcome of the survey was its educational aspect. Nearly two-thirds of respondents did not live in the area when this site was landscaped, and most of them were not aware that the neighborhood had conducted the project. Nearly one-half of all respondents expressed interest in additional landscaping at this site or nearby high-visibility, high-use sites.

96 POSTER SESSION 14 (Abstr. 398–412)**Sustainable Agriculture****Tuesday, 25 July, 1:00–2:00 p.m.****398****Three Years of Tomato Gas Exchange Response to Nitrogen Sources at Fruiting**

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The purpose of this 3-year study was to compare organic and inorganic N sources for promoting gas exchange (GE) in tomato at fruiting. Measurements of transpiration (E), photosynthesis (P_n) and internal leaf CO_2 concentration (C_i) are reported. 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. Maximum E ($14.3 \mu mol \cdot m^{-2} \cdot s^{-1}$), P_n ($22.8 \mu mol CO_2/m^2$ per s), and C_i ($352.2 \mu L \cdot L^{-1}$) occurred in 1997, 1996, and 1999, respectively. In general, E was affected mostly by treatments 2, 3, 5, and 6 and P_n by treatments 2 and 5, while treatments 1 and 4 affected C_i the most. Results indicate that N from both legumes and synthetic fertilizer enhanced GE of tomato similarly.

399**Use of Conservation Tillage and Cover Crops for Sustainable Vegetable Production**

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Research began in 1999 to examine sustainable production of bell peppers (*Capsicum annuum* L.) using conservation tillage and legume winter cover crops. Tillage treatments included conventional tillage, strip-tillage, and no-tillage, and winter covers consisted of hairy vetch (*Vicia villosa* Roth), winter rye (*Secale cereale* L.), and a vetch/rye biculture. Pepper yields following the rye winter cover crop were significantly reduced if inorganic N fertilizer was not supplied. However, following vetch, yields of peppers receiving no additional N were similar to yields obtained in treatments receiving the recommended rate of inorganic N fertilizer. Thus, vetch supplied sufficient N to peppers in terms of yields. Pepper yields following the biculture cover crop were intermediate between those obtained following vetch and rye. When weeds were controlled manually, pepper yields following biculture cover crops were similar among the three tillage treatments, indicating that no-tillage and strip-tillage could be used successfully if weeds were controlled. With no-tillage, yields were reduced without weed control but the reduction was less if twice the amount of residual cover crop surface mulch was used. Without manual weed control, pepper yields obtained using strip-tillage were reduced regardless of metolachlor herbicide application. It was concluded that a vetch winter cover crop could satisfy N requirements of peppers and that effective chemical or mechanical weed control methods need to be developed in order to grow peppers successfully using no-tillage or strip-tillage.

400**Pepper Growth and Productivity Response under Various Certified Organic Soil Treatments**

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Organic farming has increased to a \$6 billion industry in the U.S. and continues to expand 20% annually. In Iowa, organic acreage for all crops has increased

from 13,000 in 1995 to 130,000 in 1999. Most organic farmers rely on crop rotations, compost, or manure applications, and cover crops to maintain soil fertility. In our trials at the Iowa State Univ. Muscatine Island Research Farm, a cover crop of hairy vetch (*Vicia villosa*) and rye was seeded in the fall and incorporated 2 weeks prior to transplanting 'Lantern' pepper plants. Other organic and conventional soil treatments were applied at transplanting and at 3 weeks post-planting. Four replications of 40 peppers transplanted at 31 x 61-cm spacing under seven fertilization treatments were observed for plant growth and yields. The fertilization goal was to obtain equivalent nitrogen and calcium rates in the organic and conventional systems. Plants fertilized with the compost at 88 kg/ha N plus BioCal® (a liming industry by-product) were not significantly greater in leaf biomass than plants conventionally fertilized with equal amounts of N. All organic and conventional treatments had greater biomass and yield than the organic and conventional controls (no fertilizer), respectively ($P = 0.05$). Pepper fresh weight was greater in the vetch-strips treatment than in the vetch-incorporated, and the 44 kg/ha N compost treatment, but significantly less than the conventionally fertilized plants. Second year results demonstrated similar results to the 1998 trial where the greatest yields in the organic system occurred in the compost at 88 kg/ha N plus BioCal® treatment, demonstrating to organic farmers that comparable yields can be obtained in systems employing alternatives to synthetic nitrogen fertilizer.

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Effects of Allyl Isothiocyanate on Mycelial Growth from Germinating Sclerotia of *Sclerotium rolfsii*

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Isothiocyanates are volatile chemicals produced by damaged tissues of *Brassica* species. Allyl isothiocyanate (AITC), the predominant isothiocyanate in Indian mustard (*B. juncea*), has been shown to control pest in laboratory and field experiments. We investigated the effectiveness of AITC against the germination of sclerotia of *Sclerotium rolfsii* Saccardo, a common soilborne pathogen of tomato. *Sclerotium rolfsii* was cultured on PDA from a field isolate. Mature sclerotia were collected and placed in polyester mesh bags. Culture tubes (16 x 150 mm) were packed with 18 g clay loam soil. A sclerotia-bag was placed in each tube and covered with an additional 5 g soil. Soil was maintained at 60% field capacity for the duration of the experiment. AITC was injected into each tube through a septum. Treatments consisted of 0, 5.6, 11.2, 22.4, and 44.8 μmol AITC/L of atmosphere and an ethanol control. AITC in each tube was sampled using SPME and analyzed on GC-MS. Tubes remained sealed for 42 h at 30 °C. Sclerotia were then removed from tubes and bags and plated on PDA to determine viability. Radial growth was measured to determine the effects of AITC. Mycelial growth was negatively correlated to AITC concentration ($P < 0.01$). The highest concentration of AITC resulted in a 40.3% reduction in mycelial growth. Although the AITC concentrations used in this study did not kill sclerotia of *S. rolfsii*, they did suppress mycelial growth from germinating sclerotia. At higher concentrations, or mixed with other chemicals, AITC may prove to be an affective control for this pathogen.

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Compost and Solarization Affect Broccoli Head Weight, but Not Yield

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Some possible alternatives to soil fumigation with methyl bromide include soil solarization and the use of composts to modify soil microorganism populations. We tested combinations of solarization and compost on a broccoli (*Brassica oleracea* var. *botrytis* L.) crop on an organic farm. Treatments were: solarization with compost (SC); solarization without compost (SW); compost only (NC); and an untreated control (NW). Dairy manure compost was applied manually to compost plots at 22 Mg/ha, raised beds were constructed, and solarization plots were covered with clear polyethylene from 13 July to 26 Aug. Black polyethylene mulch was applied to all plots, covering the clear polyethylene. Broccoli, cv. Packman, transplants were planted into the beds and fertilized with fish emulsion fertilizer three times for a total of ≈ 22 kg/ha N. Broccoli heads were harvested on 1, 5, and 9 Dec., trimmed to 15 cm, weighed and counted. Marketable yields were 8704, 7117, 8169, and 8374 (kg/ha) and mean head weights were 353, 228, 286, 313 (g) for SC, SW, NC, and NW, respectively. Under these conditions, head weights were highest with compost and solarization, and marketable yields were similar.

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Butternut Squash (*Cucurbita moschata*) Yield and Soil Erosion in Three Tillage Systems

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Many squash varieties are large-seeded and may be well-suited for planting under no-till production systems. A study was done at the Rutgers Agricultural Research and Extension Center in Bridgeton, N.J., to evaluate the yield and loss of soil when butternut squash (BS) (*Cucurbita moschata* 'Waltham') was grown using no-till (NT), strip-till (ST), and bare ground (BG) tillage systems. The soil was a Sassafras gravelly sand loam and the field had a 3% slope. A cover crop mixture of hairy vetch and winter rye planted on 23 Sept. 1998 using a Brillion seeder at a rate of 136.2 kg/ha and 610.2 kg/ha, respectively, was used to create the NT and ST plots. NT and ST plots containing the cover crop mixture were killed with Glyphosate and chopped using a Buffalo stalk chopper on 27 May. BG plots were tilled clean before planting and ST plots were rototilled to a 30.48 cm band to establish a seedbed. BS seeds were hand-planted on 7 July with a spacing of 38.1 cm between plants and 182.9 cm between rows. Irrigation was applied overhead at a rate of 6.28 cm/ha weekly. Erosion was measured using inverted pans over the soil area to be measured. Harvest took place on 21 Oct. and yields included only marketable fruit with the following results: NT = 8.65 t/ha; ST = 8.99 t/ha; BG = 4.06 t/ha. Yields in the NT and ST plots were significantly higher than yields in the BG plots. Soil erosion measurements were taken on 21 Oct. Soil loss results from the plots were 0.08 cm (NT), 0.84 cm (ST), and 3.33 cm (BG). Soil loss, mainly due to water erosion, was significantly higher in the BG plots. BS yields can be significantly higher when using alternative tillage systems like NT and ST. When using NT and ST systems for the production of BS, soil erosion is reduced

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Cowpea Cover Crop Mulch Controls Weeds in Transplanted Bell Peppers

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A 2-year field project was conducted in Thermal, Calif., on cowpea (*Vigna unguiculata*) mulch as an alternative weed control option in pepper (*Capsicum annuum*) production. Treatments included a bare ground production system with hand weeding, bare ground with no weeding, a cowpea mulch production system with hand weeding, and cowpea mulch with no weeding. Cowpea was seeded in July in 76-cm beds and irrigated with a buried drip line. In September, irrigation water was turned off to dry cowpea plants. The cowpea plants then were cut at the soil-line to form mulch. Pepper plants were transplanted into mulch and fertilized through the drip line. Every 2 weeks, the number of weeds emerged and pepper plant heights were recorded. In December, fruit production, pepper plant dry weight, and weed dry weight were recorded. Fewer weeds emerged in the cowpea mulch than the conventional bare ground system. At harvest, weed populations in nonweeded cowpea mulch were reduced 80% and 90% compared to nonweeded bare ground for 1997 and 1998, respectively. Weed dry weights in nonweeded treatments were 67% and 90% less than weed dry weights in nonweeded bare ground over the same period. Pepper plants in cowpea mulch produced 202% and 156% more dry weight than on bare ground in 1997 and 1998, respectively. Pepper plants in cowpea mulch produced more fruit weight than in bare ground with similar fruit size. Cowpea mulch provided season-long weed control without herbicides while promoting plant growth and fruit production.

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No-till Vegetable Production in the Sand Hill Region of North Carolina

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An experiment was established to determine the effect of different winter cover crops residues on yields of no-till pumpkins, yellow summer squash, and sweet corn. Residue treatments of fallow, triticale, crimson clover, little barley, and crimson clover + little barley were fall established and killed before spring no-till planting in 1998 and 1999. All summer vegetables received recommended fertilizer rates and labeled pesticides. Spring cover crop growth and biomass measurements ranged from 1873 to 6362 kg/ha. No-till sweet corn yields among the

various cover residue treatments were greater where crimson clover and crimson clover + little barley (mixture) were used as residue in 1999, but not significantly different in 1998. No-till pumpkins showed the beneficial affect cover crop residue had on vegetable yields when dry conditions exist. Triticale and crimson clover + little barley (mixture) residues reduced soil water evaporation and produced more numbers of fruit per hectare (5049 and 5214, respectively) and greater weights of fruit (20.8 and 20.9 Mg/ha) than the other residue treatments (3725 to 4221 fruit/ha and 11.8 to 16.1 Mg/ha, respectively). No-till summer squash harvest showed steady increases in yield through time by all treatments with crimson clover residue treatment with the greatest squash yields and triticale and little barley residue treatments with the lowest squash yields. We found that sweet corn and squash yields were greater where legume cover residues were used compared to grass cover residues, whereas, pumpkin yields were higher where the greatest quantity of mulch was present at harvest (grass residues).

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Plant Diversity Influences Effectiveness of Associated Arbuscular–Mycorrhizal Fungi

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Growing a plant host in association with other plant species (i.e., increasing diversity) changes the composition of the associated arbuscular–mycorrhizal (AM) fungal community. We tested whether this alteration in the fungal community causes significant differences in the growth of *Schizachyrium scoparium* L. (Little Bluestem, a C4 grass) or *Lespedeza capitata* L. (Bush clover, a legume). Seedlings were transplanted into pasteurized soil inoculated with soil from monoculture plots of *Schizachyrium* or *Lespedeza*, respectively, vs. plots containing one, seven, or 15 additional plant species. Soil washes from a composite of the plots were added to all pots, including non-inoculated controls, to reduce differences in the non-AM microbial communities. Spore counts of the inoculum from *Lespedeza* plots showed increasing numbers of AM fungal spores and species richness with increasing plant diversity; this was not true with the *Schizachyrium* plots, possibly because *Schizachyrium* may be a better host to more species of AM fungi than *Lespedeza*. Both *Schizachyrium* and *Lespedeza* responded to inoculation with increased growth compared to non-inoculated controls. Tissue analyses of both species showed that inoculation increased the percentage of Cu, and lowered the percentage of Mn compared to control plants. *Schizachyrium* showed no significant differences in growth due to inoculum source (1-, 2-, 8-, or 16-species plots); while *Lespedeza* showed increases in root and shoot weights with increasing source-plot diversity.

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Nitrogen Retention and Release by Paper Pellets in the Bottom of Nursery Containers

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Recycled paper pellets in the bottom of containers were evaluated for retention of N from container leachate. 'Formosa' azalea were transplanted on 15 Apr. in 2.8-L containers in a pine bark/peat substrate (3:1; v/v). Treatments included paper (0 or 2.5 cm depth) in the bottom of containers and two rates of Osmocote 18–6–12 (0.68 kg or 1.36 kg N/yd³). Immediately after transplanting, plants were topdressed with 3.2 g of 12–4–6 fertilizer. Data collected included leachate samples every 2 weeks for NO₃-N and NH₄-N levels and destructive sampling every 4 weeks for shoot dry weight, foliar N, and total paper N. Nitrate-N and NH₄-N leachate concentrations were reduced with the 0.68 kg N/yd³ fertilizer rate and with paper. For example, 28 days after planting (DAP) NO₃-N leachate concentrations were reduced 36% with the 0.68 kg N/yd³ fertilizer rate and 46% with paper in the bottom of containers. NH₄-N in the leachates was reduced 53% with the 0.68 kg N/yd³ fertilizer rate and 59% with paper. Azalea shoot dry weight was not affected by paper or fertilizer rate up to 112 DAP; however, as the study progressed, plants with paper in the bottom of containers grew larger than plants in no paper treatments (29% at 168 DAP, 31% at 196 DAP). Total N absorbed by paper was not affected by fertilizer rate, and peaked at 168 DAP [980 (0.68 kg N/yd³) to 1066 (1.36 kg N/yd³) mg per container, or 41% – 28% of applied N], after which it began to decline. This decline in paper N was associated with greater growth of azalea with paper.

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Potential Use of *Typha latifolia* for Bioremediation of Metalaxyl and Simazine

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This research focused on the potential use of common cattails (*Typha latifolia*) for removing metalaxyl and simazine residues from contaminated water. Specifically, it established toxicity thresholds to the herbicide simazine and characterized the uptake and distribution of simazine and metalaxyl by the plants. Simazine tolerance levels were determined by exposing plants to a series of six concentrations (0 to 3.0 mg/L) in aqueous nutrient media for 7 days. Metalaxyl toxicity was not evaluated because other studies indicated it was relatively non-toxic to plants. Toxicity endpoints measured included fresh mass production after 7 days exposure and 7 days post-exposure. Pesticide uptake and distribution were determined by growing plants in nutrient media amended with C-14-ring-labeled metalaxyl (0.909 mg/L) or simazine (0.242 mg/L) for 1, 3, 5, or 7 days. Plants were dissected and tissues were combusted and analyzed by liquid scintillation counting. Cattail fresh mass production was reduced 84% and 117% at 1.0 and 3.0 mg/L simazine, respectively, after 7 days of exposure. Metalaxyl and simazine activity in solution was reduced 34% and 65%, respectively, after 7 days. By day 7, activity from both pesticides was detected predominantly in the leaves. Uptake of each pesticide was correlated with water uptake throughout the 7 days. These results suggest that the common cattail may be a good candidate for incorporation into a phytoremediation scheme for metalaxyl and simazine.

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Reintroduction and in Situ Conservation of 'Chococito' Maize Race in Anchicaya River, Buenaventura, Colombia

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Variability of 'chococito' maize cultivars (*Zea mays* L.), have been decreased in the Anchicaya river area, because new crops were established there. Process of recuperation, promotion, and conservation under *in situ* and *ex situ* conditions were proposed to the community of the area. Using participatory research methodologies, memory and uses were recuperated for four varieties through the Exchange Seed Interchange Fund (ESIF), established just for maize. The study was carried out in two components: social and agronomic. The social component was development in three phases: i) diagnosis; ii) establishment of the ESIF, and iii) socialization. The agronomic characterization was performed with members of the community through the development of the crop. Twenty-six variables, both quantitative and qualitative, were registered. The cultivars were appropriated for extreme conditions of the Anchicaya river area, high temperatures (30 °C) and high level of precipitation (6000 mm/year). During the process of cropping, it was found that the "to cut and to decay" system is the most common used in this region. Using multivariate analyses of quantitative and qualitative variables, the relationships between materials of 'Chococito' race were found. The dendograms for these cultivars had shown differences among them. As a complement of the *in situ* conservation done by compromise of the Anchicaya's community, a duplicate under *ex situ* conditions was established at the Genetic Resources Laboratory, belonged to the Agronomy Dept. of National Univ. of Colombia.

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Biologically Based Weed Control in Strawberry

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Lack of effective weed control is the major limiting factor in strawberry production. With few herbicides labeled for use in this perennial crop, weeds are controlled using manual labor, cultivation, and one or two herbicide applications. However, these practices do not provide long-term, effective weed control, and weeds continue to be the number one reason why strawberry fields are removed from production due to a reduction in yield. The objective of this study was to evaluate weed control during strawberry plant establishment using woven woolen mats and spring-sown canola. The effects of these mulches on weed control and strawberry plant production were studied independently and in tandem. Weed and daughter plant counts were compared among treatments to test for

differences. Wool mulch, both single- and two-ply, was an effective barrier to weeds within the strawberry rows. Planting canola between rows or broadcasting in combination with the wool mulch decreased the number of weeds when compared to other treatments. The four treatments that included wool had the highest number of rooted daughter plants when compared to all the other treatments except the weed-free plot. The canola treatments without wool mulch did not produce as many rooted daughter plants and were not statistically different from the weedy-check.

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Effect of Compost and Mineral Fertilizer Applications on the Sensory Quality of Basil (*Ocimum basilicum* L.)

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The sensory quality of fresh basil (cv. Sweet Italian) was evaluated to determine if compost or mineral fertilizer applications affected flavor and aroma intensity. The four treatments, arranged in a randomized complete-block design with three replications, were: compost applied at 50 t·ha⁻¹; compost applied at 200 t·ha⁻¹; mineral N applied at 110 kg·ha⁻¹; and a control receiving no amendment. Leaves from the first four nodes of young shoots were used in the evaluation. Twelve trained panel members scored samples of three leaves from each treatment for aroma and flavor intensity using a linear scale, converted to a scale of 1–10 where 1 = much less intense than a reference sample (control), and 10 = much more intense than the reference. No significant difference between treatments was found in flavor intensity. Significant difference between treatments in aroma intensity was found. Aroma scores were highest in samples from the compost and synthetic fertilizer treatments, and lowest in those from the control. Scores for aroma from the compost and synthetic fertilizer treatments were similar to each other. Aroma intensity increased with increased rate of compost application. No significant correlation was found between aroma intensity and plant tissue N content, sap NO₃⁻ levels, or yield.

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Organic Mulch Improves Yield and Economic Returns From Chive Production

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Chive (*Allium schoenoprasum*) is one of the most popular culinary herbs in the Virgin Islands, and local demand is always high throughout the year. However, local production is not sufficient to meet increasing demands. Chive production is constrained by insect pests, weeds, and high cost of irrigation water. A study was conducted to compare the influence of organic and synthetic mulches on yield and economic returns from chive production. The study also evaluated the effect of mulch on weeds and water use. Chives were planted in plots consisting of three rows 3.6 m long. Plants were spaced 20 cm within rows 41 cm apart. The plots were mulched with grass straw, wood chips, shredded paper, and white plastic. A control plot (no mulch) was also planted for comparison. Plots were arranged in randomized complete-block design with four replications. All plots were drip-irrigated and soil moisture tension maintained at 30 kPa. Chives grown with grass straw mulch produced taller plants and higher number of tillers (slips) than all other mulch treatments. Total fresh yield of plots with grass straw mulch was superior to all other mulch treatments including the control. On the average, plots with grass straw mulch produced 1203 g/m² of fresh chives. All mulches resulted in reduced weed population compared to the control (no mulch). Due to high rainfall during the growing season, differences in irrigation water use were not significant. Economic comparison indicated that the net return above mulch costs was 50% higher with grass straw than with other mulch treatments. To improve production and income, herb growers should consider using grass straw and realize other benefits, including weed control and improved soil fertility.

153 POSTER SESSION 22 (Abstr. 413–420)

Undergraduate Education

Wednesday, 26 July, 1:00–2:00 p.m.

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Development of a Tropical Horticulture Course on CD-ROM

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Tropical horticulture is a senior-level course in most horticulture curricula. A combination of notes, slides, and hands-on demonstration with tropical crop products is the traditional presentation format for this course. Our project integrated computer-based learning models in a comprehensive courseware package suitable for teaching an entire undergraduate tropical horticulture course covering 14 crops from the areas of fruits, vegetables, ornamentals, and floriculture. The user-friendly multimedia course includes hypertext class notes, animated graphics, videos, and pictures. The CD-ROM will be available and will be tested by students registered in the tropical horticulture class in Louisiana State Univ. and will also be translated to Spanish.

414

Biotechnology in Agriculture: A Multimedia Approach to Problem-based Learning and Distance Learning

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In 1997, we added distance students to a traditional, classroom-taught biotechnology course. To reach distance students, we used a multimedia approach: lectures via videotapes and problem-based learning exercises (PBL) via the Internet. About a third of the course was taught using PBL. The major challenge of the course was to teach the PBL segments to distance and traditional students working in groups. We explored ways to use multimedia technology that would allow distance students to participate in the PBL segments of the course. To assess the effectiveness of the methods used in this project, we compared the distance students with traditional students using measures of perceived and actual knowledge of biotechnology. The student–student interactive PBL segments were challenging because the traditional students were working in “real time” and the distance students were working in “distance time.” Distance students did as well as in the course as traditional students; however, management of groups composed of distance and traditional students was challenging. PBL could probably be used more effectively and successfully with student groups composed solely of distance students.

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A Distance Learning Website for Teaching Vegetable Crops at Virginia Tech

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A distance learning homepage at: <http://www.bsi.vt.edu/welbaum/hort4764/> was created to teach an introductory college-level course on vegetable crops to students at Virginia Tech. The course was created to serve students in the horticulture program at Virginia Beach, Va., students in the Commonwealth who cannot take classes on the Blacksburg campus, and students on the Blacksburg campus who could not schedule the classroom-based course. The course is not self-paced, but directs students through 44 lessons on various topics including detailed descriptions of 28 different vegetables. The site is primarily in HTML format with archived student projects and old exams in PDF format. Audio clips are used to emphasize key information and to add a personal touch. There are >550 pictures and descriptions of vegetables and vegetable crop production linked to the website. Students can be examined using a computer testing system called Whizquiz that grades and corrects each exam. “Web Forum” software enables online discussion among students and the instructor. Discussion sessions have been successfully conducted between students and guests at distant locations. Links are provided to over 25 other websites with information on vegetable crops. The project was funded by a USDA/CSREES Higher Education Challenge Grant.

416

An Update on Taxonomic Name Changes in Some Tropical Ornamental Plants

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A new name for an old plant is not necessarily welcome in the horticultural trades or in plant identification classes, but some name changes have been in existence long enough that textbooks and trade publications should have caught up with them. The objective of this poster is to call attention to some of these changes for horticultural plant identification courses. Traditional references such as *Hortus Third* (1976) and *Exotica 8* (Graf, 1976) have been superseded by the second edition of *The Plant Book* (Mabberly, 1997) and *The Index of Garden Plants* (Griffiths, 1994), while some recent works (*The Tropical Look*, Riffle, 1998) have chosen to retain old names. The taxonomic research underlying a new book, *Tropical Garden Flora* (Staples and Herbst, in press), based on the second edition of *In Gardens of Hawaii* (Neal, 1965), has produced an abundance of name changes. This poster will illustrate and report genera and species name changes that have occurred for selected ornamentals in the Acanthaceae, Agavaceae, Araceae, Araliaceae, Arecaceae, Commelinaceae, and Moraceae families plus a few others.

417

The Development of Virtual Campus Plant Walks to Aid in the Learning of Ornamental Plants

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The Univ. of Connecticut has designed a website that will help facilitate the learning of landscape plant material. The main objective of this site is to help students taking plant identification courses in New England's land-grant universities and one private college. Virtual Campus Plant Walks have been developed to address budget constraints, student demands for technology integration in the classroom and to make use of the pedagogical benefits of the internet medium. The Virtual Campus Plant Walks are on-line walks that have detailed pictures and information given during actual plant walks done in each plant identification laboratory. Students are able to retake the walks at their own pace, reevaluate a plant they are having trouble remembering, or take the walk over the internet for the first time if they were unable to attend lab. Students will now be able to study plant material whenever they want, regardless of the time of day or weather. The educational validity of the walks has been tested for three semesters and the results are favorable. Surveys reveal that 80% believe the website improved their grades and 76% claimed the website decreased their study time. This evidence will promote the continued and expanded use of the website.

418

Results of an Ornamental Horticulture Survey Conducted at High Schools in Illinois, Iowa, Minnesota, and Wisconsin

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Fifty high schools were surveyed in northwestern Illinois, northeastern Iowa, southeastern Minnesota, and Wisconsin to determine the number of students interested in pursuing a horticulture degree at a 4-year university. Students were asked several questions pertaining to horticulture. About 45% of our surveys were returned. Of the 451 surveys received, about 47% of the high school freshman, sophomore, junior, and seniors indicated that they were interested in horticulture. About 41% of the students interested in horticulture wanted to work in landscaping, 20% greenhouse, 14% florist shop, and 7% in turfgrass management. About 70% of the students indicated that they wanted to own and operate their own horticultural business. Almost 53% of the students indicated that they would prefer an emphasis/minor in Agribusiness or Business Administration compared to plant and soil science (19%), biotechnology (14%), plant breeding and genetics (13%), or comprehensive horticulture (1%) in combination with their horticulture degree. The above information was used by our School of Agriculture and Depts. of Biology and Business and Accounting to develop a major in Ornamental Horticulture.

419

A Laboratory Demonstration of Water Stress on Plant Growth

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Students in plant science courses have difficulty thoroughly understanding the effect of water stress on net photosynthesis and its consequences—reduced plant growth, productivity, quality, and profit. A laboratory demonstration utilizing a controlled water table irrigation system (CWT) provides a nearly constant plant water potential. Pots are placed on a capillary mat with one end suspended in a trough with nutrient solution. The vertical distance from the solution surface to the pot bottom determines the water potential; the water potential is 0 when the pot bottom is at the same level as the nutrient solution. The greater the vertical distance from solution to the pot bottom, the lower the water potential. For this demonstration, the bench was sloped from 0 to 10 cm above the solution over a distance of 90 cm. Corn, squash, soybean, fescue, and marigold seed were directly sown to either 9- or 15-cm pots and then placed on the CWT sloped bench at five vertical distances above the solution. Weekly, students observed plant growth and at the end of 8 weeks evaluated root and shoot growth. For all species, plant growth was indirectly related to the distance above the nutrient solution. Plants at near 0 water potential were much larger than those grown 8 to 10 cm above the solution.

420

Creating a Synchronous Course between Universities Using Distance Technologies

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A model for the creation of shared synchronous courses between universities has been developed based on our experiences during the development and delivery of an upper-level undergraduate/graduate course in Plant Nutrition and Nutrient Management offered by Kansas State Univ. and the Univ. of Nebraska-Lincoln. The course was conducted during the Spring 1999 semester using two-way compressed video so that instructors and students at both sites could see and hear each other in live time. Our model is set up as a flow-chart and currently has 10 steps that include areas such as "Identifying the Need," "University Must-Do's," "Distance Class Technology Requirements," and "Advertising the Course." Each step details procedures to follow, offers ideas and suggestions, and includes examples taken from our course. Also included is information about web site development and chat room use. The model is easily adapted for use with distance technologies similar to two-way compressed video such as Internet 2. An electronic version of the model can be accessed at http://www.oznet.ksu.edu/dp_hfrr/Floriculture.

45 POSTER SESSION (Abstr. 421–427) Collegiate Branch Poster Competition

421

Thermodynamic Analysis on Mechanism of Deep Supercooling of Tissue Water in Winter-hardy Plants

Fanyi Shen*¹, Rongfu Gao², Wenji Liu³, Wenjie Zhang¹, and Qi Zhao⁴; ¹College of Basic Science and Information Engineering, Beijing Forestry University, Beijing, P.R. China; ²College of Biology Beijing Forestry University, P.R. China; ³Department of Basic Courses, Zhengzhou Institute of Light Industry, P.R. China; ⁴Department of Biology, Capital Normal University, P.R. China

It is known that the redistribution of water and the formation of dispersed water units appears to be a prerequisite for deep supercooling. A concentration of the cell solute results from the migration of water during extracellular freezing and lowers the temperature of homogeneous nucleation, but we are convinced that nucleation of ice within cells may be initiated by a heterogeneous mechanism, except we consider a small spherical cave, the water can freeze on the wall of this cave. We are also convinced that the solid walls of the capillary exert an external potential on the water molecules, causing the shift of the triple point of the confined fluids. Based on Fletcher's work for spherical particle, we have gotten the formula of critical free energy in the process of heterogeneous nucleation

of water in a small spherical cave. This presentation introduces the theoretical background and counts the drop of temperature in heterogeneous nucleation. Then, putting two actions (depression of triple point and process of heterogeneous nucleation) together, we have calculated the freezing point. Sometimes it is lower than -38°C . Some phenomena can be explained by using this theory: 1) Water is at the tension status, which means that it wets plant tissue, so the triple point (melting point) of tissue water can be lowered. 2) The redistribution of water, formation of dispersed water units, and dry region preventing ice from propagating, all allow heterogeneous nucleation, then the two actions can be synthesized and the water would lead to deep supercooling. If the barriers were destroyed, heterogeneous nucleation and deep supercooling would certainly be lost. 3) This theory is only suited to rigid wall of small cave, so we understand why cell wall rigidity has been shown to affect freezing characteristics. Project 39870234 supported by National Nature Science Foundation.

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Water Uptake Patterns in *shrunken-2* Sweet Corn (*Zea mays*) during Imbibition of Film-coated Seeds

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Membrane damage associated with rapid influx of water during imbibition can play a role in the poor emergence and seedling vigor associated with sweet corn germination. Film-coating as a seed treatment has been used to improve germination and vigor in sweet corn and this improvement may not be associated with changes in imbibition rate. Two seed lots of *shrunken-2* variety sweet corn, low-vigor 'Even Sweeter' and high-vigor 'Sugar Bowl', were treated with a hydrophilic polymer film-coating and evaluated for differences in emergence and water uptake. Both cultivars were grown at 19, 21, and 26 $^{\circ}\text{C}$ with no effect on emergence due to film-coating. Imbibition curves were established for untreated and hydrophilic film-coated seeds. Film-coated seeds showed an 18% increase in fresh weight compared to untreated seeds for both cultivars during a 6-h period. Bulk conductivity tests resulted in no significant mean difference between untreated and hydrophilic-treated seeds after 24 h. These seed lots have been treated with a hydrophobic polymer and are currently being evaluated for cold temperature emergence and imbibition rates. Water entry during imbibition will also be compared for untreated *sugary (su)* and *shrunken-2 (sh2)* seeds using the fluorescent compound trisodium salt, 8-hydroxypyrene-1, 3, 6-trisulfonic acid (HPTS).

423

Tensiometer-controlled Irrigation in Large Container-grown Bald Cypress (*Taxodium distichum*)

Virginia Thaxton*, Ed Bush, Ann Gray, and Paul Wilson; Department of Horticulture, Louisiana State University, Baton Rouge, LA 70803

Proper irrigation practices are important in the production of container-grown woody ornamentals. When choosing irrigation methods, nurserymen must attempt to maximize production and comply with public policies mandating decreased water usage and runoff. One of these methods schedules irrigation based on plant demand, using tensiometers to measure matric potential of the substrate. While tensiometers have been used successfully with agronomic crops in the field, their effectiveness in irrigation management of large container-grown woody ornamentals has not been extensively tested. The objective of this study was to determine the effect of four irrigation treatments (7 cb tensiometer setting, 14 cb tensiometer setting, 1 time a day application, 4 times a day application) on the production of the ornamental tree Bald Cypress over a 9-month period. Growth differed significantly among treatments. The highest growth index was observed in the 4 times a day and the 7 cb tensiometer treatments, followed by the 1 time a day and 14 cb treatments, respectively. Effluent and leachate (pH, EC, N, P, K) were also measured. Percent effluent volume was highly variable, with maximum volume occurring in June for the 7 cb setting (82%) and in October for the 1 time a day treatment (47%). Higher pH values (7.0 to 8.0) initially occurred in the timed irrigation treatments and higher EC values (2.0–6.0 mmhos) were found in tensiometer treatments; over time, differences among treatments decreased for both variables. Substrate concentrations of N, P and K varied significantly among treatments, while no significant differences were found in the leaf tissue analysis.

424

A Comparison of Techniques Used for Determining Freezing Injury on Two Apple (*Malus x domestica* Borkh.) Cultivars: Liberty and RedMax

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Hardiness testing of the wood of deciduous fruit trees has been conducted using a variety of techniques. In our studies, the objective was to determine an efficient method of determining freezing injury for apple (*Malus x domestica* Borkh.) wood. We tested 1-year old wood of two cultivars: Liberty and RedMax. The wood was tested over the course of 2 years (1998 and 1999). Collection began in the late fall and continued throughout the winter (until it was determined full hardiness had been achieved) and then again in the early spring. The wood was cut into 1-cm sections and frozen. The artificial freezing was conducted in an ethanol bath, with the temperature lowered at 5 $^{\circ}\text{C}/\text{h}$. Samples were removed in 3-min intervals. After freezing, the wood was acclimated to 4 $^{\circ}\text{C}$ for 12 h. Three tests were conducted to determine the hardiness/injury to the tissues. The tests used were: discoloration, callus growth and vital staining (with 2,3,5-triphenyltetrazolium chloride). This was a split block design with samples collected randomly from each tree. Four replicates (12 trees) of each cultivar were tested. Results showed that the callus test predicted the same LT_{50} as the other two tests, discoloration and vital staining. Discoloration was not easy to differentiate and was the most time-consuming. The callus grown by the apple wood was easily formed and distinguished. The callus test does not require the tetrazolium stain; therefore, one less step was needed in comparison to the vital staining test. This reduced testing time by over 6 h.

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Comparisons of Mechanical Scarification Techniques for Enhancing Seed Germination in Two Saltgrass (*Distichlis spicata*) Seed Lots

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Native turfgrasses have received greater attention in recent years because of their usefulness in growing in areas where many other grasses cannot. Saltgrass (*Distichlis spicata*) has good salt tolerance, but the natural germination rate for the seed is low. This is most likely due to the thickness of the seed coat inhibiting normal imbibition of water. Previous research in our laboratory has demonstrated increased germination with hand-scarification. The purpose of this research was to compare germination rates of machine-scarified, hand-scarified, and non-scarified seed. Scarifying the seeds by hand results in greater uniformity, but the operation is tedious and time-consuming. Machine scarification is quick, but the seeds have reduced uniformity. Two seed lots, one designated "Modoc" and one designated "Granite," were compared in laboratory and field germination tests. Preliminary observations have shown that "Granite" seed had somewhat higher viability and vigor than the "Modoc" seed. Significantly greater germination occurred with scarification when seeds were germinated at 14 h of light at 30 $^{\circ}\text{C}$ and 10 h of darkness at 20 $^{\circ}\text{C}$ in the laboratory. Although scarification treatments were similar with the "Granite" seeds, near 80% germination, there were significant differences between hand and machine scarification with the "Modoc" seeds; hand scarified seed had greater germination. The field germination experiment had similar results to the laboratory experiments with "Granite" seed. However, scarification did not aid germination of "Modoc" seed. This is thought to be due to low vigor and associated death of seedlings prior to emergence. Preliminary data confirm the low vigor of the "Modoc" seed as compared to "Granite" seed.

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Deer Response to Selected Plant Extracts

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Feeding damage by white-tailed deer to vegetable and ornamental crops are often adverse to plant growth, and result in economic and aesthetic losses. While the efficacy of commercially available deer repellent products is questionable, plant extracts may provide an environmentally sound alternative to traditional chemical treatments. Commercially available plant extracts (Dusty Miller, peppermint, Madagascar periwinkle, wax myrtle, barberry, juniper, geranium, rosemary, lemon balm, and yucca) known to be unpalatable plants were chosen as treatments. Thiram and putrescent egg spray were used as positive controls along with a no-spray treatment. Gomphrena were grown off-site in trade gallon pots

and used as test plants. Sixteen deer were confined in two 1-acre study pens at the Auburn Univ. Deer Research Facility. Feeding damage was recorded daily using a 0 to 3 rating scale corresponding to 1/3, 2/3, and complete destruction, respectively. All damage data were converted into percent damage. Barberry and wax myrtle extracts made gomphrena more palatable to the deer as feeding damage exceeded that of the untreated plants. However, lemon balm, rosemary, yucca, and peppermint provide some level of protection against feeding damage to gomphrena. Fifth-day damage ratings for these extracts were 37%, 35%, 13%, and 19%, respectively. Fifth-day damage for untreated plants was 40%. Peppermint and yucca extracts appear to be promising alternatives to thiram and putrescent egg-based products.

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Inheritance of the Albino Trait in Daylily

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The albino genetic characteristic is a lethal condition in the post-seedling stage in plants. Although, it is an undesirable genetic characteristic, it is however an interesting genetic condition that can be utilized as a good practical genetic exercise for plant genetic and breeding courses. In this study, four commercial hybrid varieties of Hemerocallis were crossed as followed: A) "Stella D'ora" (with light orange flower) x "Happy Return" (with yellow flower); B) "Dark-eyed Magic" (purple with pink/cream variegated flower) x "Stella D'ora" (yellow flower). The seeds from these crosses were harvested and germinated in a plastic flat containing metromix 500 soil medium and placed under greenhouse condition. The germination of the seeds from each of the crosses resulted in the expression of green and albino seedlings in the F₂; showing the typical Mendelian segregation of a dihybrid cross. Green was found to be dominant to albino. All the albino seedlings withered and died 2 weeks after germination. All four commercial hybrid varieties are carrier of the albino recessive gene.

22 ORAL SESSION 1 (Abstr. 428–435) Woody Ornamentals/Landscape/Turf: Physiology & Nutrition Monday, 24 July, 8:00–10:00 a.m

428

Nitrogen Form Affects Growth, Mineral Nutrient Content, and Root Anatomy of Cotoneaster and Rudbeckia

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Five ratios of NH₄:NO₃ (100:0, 75:25, 50:50, 25:75, and 0:100) were evaluated for impacts on growth of *Cotoneaster dammeri* Schneid. 'Skogholm' (cotoneaster) and *Rudbeckia fulgida* Ait. 'Goldsturm' (rudbeckia). Nitrate decreased dry weight and leaf area, while nutrient solutions containing >25% NH₄ increased shoot and root growth of cotoneaster and rudbeckia. Additionally, NO₃ decreased accumulation of some cationic nutrients and N in roots and shoots of cotoneaster and rudbeckia compared to solutions containing either NH₄ alone or mixes of NH₄ and NO₃. Nitrogen contents (in milligrams) in cotoneaster fertilized with NO₃ decreased an average of 54% and 58% in rudbeckia compared to N supplied as NH₄ alone. These dramatic reductions in growth and tissue nutrient content reiterate the need for proper N form selection. Root diameter of cotoneaster was higher with a mix of NH₄ and NO₃ than with NO₃ alone; whereas, the N form had no impact on diameter of rudbeckia roots. However, the stele of both cotoneaster and rudbeckia roots was larger and contained more secondary xylem with larger tracheary elements with a mix of NH₄ and NO₃ compared to nutrient solutions with NO₃ alone. Increased number and size of secondary tracheary elements may relate to increased dry weight and leaf area of both cotoneaster and rudbeckia fertilized with mixes of NH₄ and NO₃ compared to NO₃ alone.

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Detecting Incipient Water Stress in Buffalograss and Kentucky Bluegrass through Foliage Temperature using Low-cost Infrared Sensors

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Infrared sensors were used to quantify canopy temperature and thus detect differences in incipient water stress between a cool-season grass [Kentucky bluegrass (KBG) (*Poa pratensis*)] and a warm-season grass [buffalograss (BG) (*Buchloe dactyloides*)]. The infrared sensors, connected to a datalogger, measured average hourly leaf-air temperatures (TL-TA) 1 m above eight replicate plots of Kentucky bluegrass and eight replicate plots of buffalograss. Air temperature and relative humidity from a nearby weather station were used to calculate the average hourly vapor pressure deficit (VPD). In late July, we ceased irrigating and measured TL-TA and soil water content while allowing the turf to dry down for 5 weeks. Soil water content was measured with a neutron probe. Both species exhibited a significant relationship between TL-TA and VPD. As the VPD increased, TL-TA decreased in both species (KBG $r^2 = 0.73$, BG $r^2 = 0.71$) on the 2nd day after an irrigation during well-watered conditions. An artifact was created on the first day after an irrigation as a result of excessive surface evaporation. KBG and BG were similar under well-watered conditions. KBG had a higher TL-TA after 4 to 5 days without irrigation. By contrast, BG did not have a higher TL-TA until 25 to 30 days without irrigation. Part of BG's drought avoidance was extraction of soil water down to 0.9 m vs. 0.45 m for KBG.

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Ecotype Affects Growth and Flowering of *Rudbeckia hirta* L.

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Evidence is presented that native populations of *Rudbeckia hirta* L. (Black-eyed Susan) may be adapted to regional conditions. Two Florida ecotypes, one from north Florida (NFL) and one from central Florida (CFL), were better able to withstand the low fertility sites under three AHS Heat Zones (9, 10, 11) in Florida than were plants grown from Texas (TEX) seeds. Plants from TEX seed were the largest and showiest (generally the greatest number of flowers; largest flowers) but the shortest-lived. Most of these plants did not survive beyond August (about 6 months after transplanting) regardless of site. The CFL plants were especially tolerant of flooding conditions at Ft. Lauderdale. Under garden conditions, CFL Black-eyed Susan may be a highly desirable wildflower for subtropical or tropical summers.

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Seasonal Changes in Nitrogen Uptake Efficiency in a Woody Ornamental (*Tilia cordata* Mill. 'Greenspire')

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Fertilizer recommendations for woody ornamentals suggest applying nutrients in early spring at budbreak, and in fall at the time of leaf coloration or leaf abscission. Because plants lack functional leaves at those times, there would be minimal contributions from photosynthesis to active ion absorption or from transpiration to mass flow of ions in soil towards roots. Thus, we hypothesized that fertilizer efficiency also would be low at those times. To estimate N uptake efficiency, ¹⁵N-enriched fertilizer was applied to container linden trees at one of five times during the 1998 season: at budbreak, during active growth, after terminal bud-set, before leaf abscission, and during leaf abscission. Half of the plants received ¹⁵N-nitrate-enriched ammonium nitrate on each date, and half received ¹⁵N-ammonium-enriched ammonium nitrate. Treated plants were harvested 10 days after enriched fertilizer application (29 May, 6 July, 17 Aug., 28 Sept., and 16 Nov.). Patterns of uptake were not different between plants treated with ¹⁵N-ammonium- or ¹⁵N-nitrate-enriched fertilizer. In both cases, nitrogen recovery efficiencies at budbreak and leaf abscission were much lower than at other application times. Whole-plant recovery efficiency of ¹⁵N-nitrate-enriched ammonium

nitrate was 10% at budbreak, 13% at leaf abscission, and ranged from 58% to 71% for the intervening times. Recovery of ^{15}N -ammonium-enriched ammonium nitrate was 6% at budbreak, 24% at leaf abscission, and 42% to 56% for intervening times.

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Irrigation Frequency Affects Growth and Water Use Efficiency of Two Xeriphytic Landscape Plants

Linda B. Stabler* and Chris A. Martin, Dept. of Plant Biology, Arizona State Univ., PO Box 871601, Tempe, AZ 85287-1601

Growth and water use efficiency (WUE) of two Southwest landscape plants under various regimes of irrigation frequency was studied in a greenhouse experiment. Red bird of paradise (*Caesalpinia pulcherrima* L.) and blue palo verde (*Cercidium floridum* Benth. ex A. Gray) were grown at three levels of irrigation frequency intended to mimic a range of watering practices determined via survey data from the Phoenix, Ariz., metropolitan area. During two irrigation cycles, measurement of mid-day water and osmotic potentials, lysimetric whole-plant transpiration (T), and mid-day shoot gas exchange was made. Irrigation frequency treatments affected *Cercidium* more than *Caesalpinia*. Frequent irrigations increased *Cercidium* shoot length and dry weight. For both species, infrequently irrigated plants showed patterns of osmoregulation in response to drying soil. Transpiration (T) was consistently highest for infrequently irrigated plants. WUE was affected by treatment for *Cercidium*, but not *Caesalpinia*. Gas exchange was unrelated to plant growth or T. Instantaneous transpiration efficiency (ITE) was negatively correlated to the ratio of intracellular CO_2 to ambient (CICA) in all treatments, suggesting that under well-watered conditions, WUE might be reduced by negative feedback effects of high internal CICA ratios.

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Phosphorous and Potassium Fertilizers Influence Establishment of Bermudagrass

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Establishment of an acceptable turfgrass quality on sand-based golf putting greens presents major agronomic and environmental challenges to turfgrass managers. The objective of this study was to evaluate of five N:P:K fertilizer ratios to aid in the establishment of bermudagrass on sand-peat (85:15 v/v). 'Floradwarf' and 'Tifdwarf' bermudagrass [*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burt-Davy] were sprigged in Aug. 1996 at the Envirogreen in Gainesville, Fla. 'Tifeagle' and 'Tifway' bermudagrass were sprigged in May 1999 at Clemson Univ. research green in Clemson, S.C. Treatments consisted of N:P₂O₅:K₂O ratios of 1:0:1, 1:0:2, 1:1:1, 1:2:1, and 1:3:1 applied based on an N rate of 49 kg/ha per week. Treatments were applied weekly for 7 weeks. In Gainesville, the best growth rate was achieved from the 1:1:1 ratio of N:P₂O₅:K₂O. While the 1:2:1 and 1:3:1 plots filled in well, they did not experience the same coverage rates as plots fertilized with the 1:1:1 ratio. In Clemson, similar growth was achieved with the 1:1:1, 1:2:1, and 1:3:1 treatments. The 1:0:1 and 1:0:2 plots were slow to establish at both locations. In general there were no differences in root and shoot dry weights of grasses grown in Clemson; whereas these weights were positively correlated to growth rates in Gainesville. These studies indicate that turf will respond to P fertilizer when it is grown in a P-deficit situation and that N or K cannot substitute for balanced nutrition.

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Environmental Risk Assessment—A Nutrient Management Planning Strategy For Nursery and Greenhouse Systems

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In 1998, the state of Maryland adopted some of the toughest nutrient management planning regulations in the Nation, requiring virtually all agricultural operations plan and implement nitrogen and phosphorus-based management plans by Dec. 2002. The nursery and greenhouse industry is faced with a far more complicated nutrient management planning process than traditional agronomic planning scenarios. Factors include a large number (>500) of plant species, various fertilization and irrigation strategies, with crop cycles ranging from 6 weeks (bedding plants) to upwards of 15 years for some tree species in field production, often with a lack of knowledge of specific nutrient uptake rates and utilization. In addition, unique infrastructural and site characteristics that contribute to water and nutrient runoff from each nursery contribute to a multitude of variables that

should be considered in the planning process. The challenge was to identify a simple, effective process for nutrient management planning that would a) provide an accurate assessment of nutrient loss potential from this wide variety of production scenarios, b) identify those specific factors that contribute most to nutrient leaching and runoff, and c) provide a mechanism to economically assess the various risk management (mitigation) scenarios. This risk assessment process provides information on a number of fixed (site) and dynamic (management) variables for soils/substrates, irrigation and fertilization practices, together with any surface water management systems (e.g. containment ponds, riparian buffers). When all the risk factors for a nursery are evaluated and scored, the complete picture of risk assessment then emerges. By identifying higher risk factors and evaluating different risk management options, the grower and/or nutrient management planner can then choose economic alternatives to reduce the potential for nutrient runoff.

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Seasonal Amplitude and Distribution of Elevated Atmospheric CO₂ in Phoenix, Arizona, USA

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Combustion of fossil fuels in urban areas might increase local atmospheric CO₂ concentrations and could result in an urban to rural CO₂ concentration gradient. Our objective was to ascertain if such a CO₂ gradient exists and to characterize seasonal patterns of amplitude and distribution of atmospheric CO₂ concentrations in the Phoenix, Ariz., metropolitan, area. Atmospheric CO₂ concentration was measured along a series of gradients that transected the greater Phoenix metropolitan area in June 1999, in Dec. 1999, and Jan. 2000. Carbon dioxide concentration was measured with a portable infrared gas analyzer in open system mode from a mobile vehicle traveling at a constant rate of speed. All measurements were made around 0500 and 1500 HR on days when weather conditions were clear and calm. The CO₂ intake port was located above the vehicle at a height of 2.5 m. Data were categorized based on distance from the Phoenix urban core, defined as the intersection of Central Avenue and Van Buren Street. Gradients of high to low CO₂ concentration existed from city center to outlying rural areas. Carbon dioxide concentrations were highest during winter and varied most during the afternoon. Mean CO₂ concentrations in central Phoenix were 12% higher than surrounding rural areas during summer, but were up to twice as high as rural areas during winter. We conclude that there is a potential for atmospheric CO₂ fertilization of plants in the Phoenix area, particularly of urban landscape plants that are biologically active during winter.

23 ORAL SESSION 2 (Abstr. 436–441)

Cross-commodity: Postharvest Physiology & Food Science

Monday, 24 July, 8:00–9:30 a.m.

436

1-Methylcyclopropene and Waxing Regulate the Ripening Storage Life of Avocado Fruit

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1-Methylcyclopropene (1-MCP), an inhibitor of ethylene action, has been shown to extend the storage life of avocado fruit. Waxing is also known to extend the storage life of avocado by reducing water loss and modifying the fruit internal atmosphere. In this study, 1-MCP and waxing were used to investigate their effects on ripening characteristics in avocado fruit. Preclimacteric 'Tower II' and 'Booth 7' avocados were treated with 1-MCP (EthylBloc®) for 12 h at 20 °C. Half of the fruit were waxed (Sta-Fresh 819F®, FMC Co.) after 1-MCP treatment. The fruit were subsequently stored at 13 °C or 20 °C at 85% RH. As evaluated by fruit firmness, ethylene evolution, and respiration rate, 1-MCP and waxing delayed the ripening of 'Tower II' avocados stored at 20 °C. Fruit treated with both 1-MCP and wax had better retention of green peel color and fruit firmness, and the delayed climacteric pattern of ethylene evolution and respiration rates. Waxing reduced weight loss and retarded softening, but did not delay climacteric ethylene evolution and respiration rates. Whereas firmness of control fruit decreased from

>100 N to 20 N in as few as 7 days at 20 °C, fruit treated with both 1-MCP and wax reached 20 N over 11 days at 20 °C. The firmness of 'Booth 7' avocados treated with both 1-MCP and wax decreased from >170 N to 20 N over a 5-week period at 13 °C. Current studies are addressing the nature of the dramatic decrease in firmness of MCP-treated fruit.

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Development of Safe Working Atmospheres for Enhanced Storage of Horticultural Crops

N.A. Mir^{1,2} and R.M. Beaudry¹; ¹Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824; ²EPL Technologies, Inc. Philadelphia, Pa.

O₂ and C₂H₄ are biologically active molecules of importance in plant metabolism and their availability is manipulated to modify plant behavior during storage and the shelf-life period of harvested plant products. Respiratory curves describing the dependence of O₂ uptake on O₂ were obtained for slicing and 'Roma'-type tomato, and 'Jonathan' and 'Empire' apple fruit at 20 °C for ripening fruit and for mature, non-ripening fruit. Mature, non-ripening fruit were maintained in that state by the application of 1-methylcyclopropene (1-MCP) or the use of a non-ripening mutant in the case of tomato. The range of O₂ atmospheres wherein the reduction of O₂ relative to ambient yielded a significant (50%) reduction in respiration relative to the maximal rate of respiration, but was above the fermentation threshold, was termed the 'safe working atmosphere' (SWA). For apple, there was no SWA for non-ripening apple fruits since a 50% reduction in respiration occurred at the fermentation threshold. During ripening, the respiratory curve shifted, revealing a marked increase in the apparent Km and maximal rate of respiration with no change in the fermentation threshold, resulting in the creation of a SWA of 6.5 kPa O₂. A similar, less dramatic, shift in the respiratory curve for tomato fruit also occurred. In a flow-through system, low O₂ reduced the rate of respiration of ethylene insensitive tomato fruit by ≈50% and resulted in an approximate doubling of the storability of the fruit. Insensitivity to ethylene yielded fruit with a respiratory rate approximately one-half that of ripening fruit, but storability was improved about 5-fold. The data collectively suggest that inhibition of ripening, rather than global metabolism via reduced respiration is key to preserving fruit quality.

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Use of 1-MCP to Reduce the Requirement for Refrigeration and Modified Atmospheres in the Storage of Apple Fruit

R.M. Beaudry¹ and N.A. Mir^{1,2}; ¹Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824; ²EPL Technologies, Inc. Philadelphia, Pa.

The growth regulator 1-methylcyclopropene (1-MCP) is a vapor under physiological conditions and acts by inhibiting the binding of the hormone ethylene to its binding site and a single exposure can temporarily render plant material insensitive to ethylene when applied at the parts-per-billion level. Apple fruit were harvested 1 week prior to the climacteric (harvest 1), at the onset of the climacteric (harvest 2), and 1 week after the onset of the climacteric (harvest 3). Fruit were stored at 0, 5, 10, 15, and 20 °C and were given treatments with 1 ppm 1-MCP on a once-per-week, once-per-2 weeks, once-per-month, and once-per-year basis or were left untreated. In terms of reduced softening, earlier harvested fruit were more responsive to the 1-MCP treatment and the efficacy of 1-MCP was enhanced by repeated application. At 20 °C, control fruit (all harvests) softened to less than 50 N pressure within 20 days. For fruit treated once with 1-MCP, fruit of harvest 1 reached this threshold by 63 days, those of harvest 2 after 56 days and those of harvest 3 by 40 days. Fruit treated on a once-per-month basis began to soften by 56 days for harvest 3, while those of harvest 1 and 2 did not. Fruit treated once per week or once per 2 weeks did not soften relative to initial firmness (68N) during the first 63 days of the study. 1-MCP effectively prevented softening at all temperatures relative to the controls, however, as temperature decreased, the benefits of 1-MCP application became less pronounced. Decay was a significant problem for fruit stored at 15 and 20 °C storage temperatures. Roughly 30% to 60% of the fruit were lost to decay in the first 60 days of the study. 1-MCP application reduced, but did not prevent decay. Storage of 1-MCP-treated apple fruit at elevated temperatures will likely require some means of controlling decay in storage.

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Cultivar Variation in Response to 1-Methylcyclopropene Application to Apple Fruit in Air and Controlled-atmosphere Storage

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The inhibitor of ethylene binding, 1-methylcyclopropene (1-MCP) has been applied to 'Gala', 'Cortland', 'McIntosh', 'Empire', 'Delicious', 'Jonagold', and 'Law Rome' apples under air and/or controlled atmosphere (CA) storage conditions. 1-MCP gas concentrations ranged from 0 to 2 mL·L⁻¹. Effects of 1-MCP were greater in CA than air storage. A dose response of internal ethylene concentrations and flesh firmness to 1-MCP was found in cultivars such as 'McIntosh' and 'Law Rome', whereas in others, such as 'Delicious' and 'Empire', ripening was generally prevented by all 1-MCP concentrations. We have further investigated the effects of 1-MCP on 'McIntosh' by increasing rates of the chemical to 50 mL·L⁻¹, and confirming that fruit of this cultivar respond poorly if fruit have entered the climacteric prior to 1-MCP application. Efficacy of 1-MCP is affected by cultivar and storage conditions, and that successful commercial utilization of the chemical will require understanding of these relationships.

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Effects of UV-B Irradiance on Postharvest Quality and Storability of Hand-picked Rabbiteye Blueberry as Related to Maturity Stage and Harvest Time

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Blueberry fruits (*Vaccinium ashie* Read) of two cultivars, 'Delite' and 'Woodard', were hand-picked twice during the growing season (15 June and 1 July) to study the benefits of UV-B irradiance on postharvest fruit quality. After precooling, healthy, disease-free, uniform fruits were selected and exposed to UV-B irradiance (180 to 310 nm) for 24 h under cold conditions. The fruits were then kept at 2–3 °C and 90% to 95% relative humidity for 2 weeks before determining their quality parameters. Irradiated fruits were softer, wrinkled, and non-marketable compared to non-irradiated berries. UV-B had no beneficial effects on fruit quality or storability.

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Nondestructive Quality Evaluation in Strawberries by Means of Chlorophyll Fluorescence

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The possibility of using chlorophyll fluorescence for detecting internal quality of strawberry has been investigated. The mature fruit were marked and stored at 0 and 5 °C for 5, 10, and 15 days. After storage they were placed in the dark for 20 min and fluorescence measurement then was taken at the marked place with a fluorescence probe with a light intensity of 20 μmol·m⁻²·s⁻¹. Samples were also taken from the marked place for laboratory analysis to determine chlorophyll and total soluble solute content. Firmness was detected by an Instron Universal Testing Machine taking measurement at the marked section of the fruit. Rot was detected visually. Multiple regression and simple correlation were detected between fluorescence and laboratory-analyzed data. Multiple correlation coefficient (*R*) ranged from 0.80 to 0.97. Simple correlation (*r*) ranged from 0.44 to 0.89. The results of this study indicated that chlorophyll fluorescence is capable of detecting internal quality of strawberry and may potentially extend to other fruits. Feasible applications of the method include packinghouse, sorting of fruits, and parent and progeny quality assessment in a strawberry breeding program.

24 ORAL SESSION 3 (Abstr. 442–448 & 618)
Floriculture/Foliage: Production
Monday, 24 July, 8:00–10:00 a.m

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Evaluation of Fungicide Treatments for Disease Protection of *Zantedeschia elliotiana* 'Flame' in Florida Calla Lily Production

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Zantedeschia elliotiana 'Flame' is a yellow calla with unique rust-colored blush, which is prone to a fungal/bacterial disease complex. Keeping calla rhizomes healthy and free of weakening by the most common fungal organisms *Fusarium* and *Rhizoctonia*, which minimizes secondary invasion and toppling by *Erwinia carotova* soft rot, the most prevalent cause of calla loss in production. Rhizomes were treated by pre-plant bulb dip or post plant drench either with fungicide or bactericide alone or in combination. Pot loss totaled with plants showing a lack of vigor resulted in 8%, 12%, and 14% loss in the most effective three treatments, which were: 1) the common commercial pretreatment (Champ II, Dithane, and Agrotol) 2) control plants and 3) RootShield (*Trichoderma harzianum* T-22). Upper (leaf and stem) plant fresh weights corresponded having heaviest weights of 47.8, 53.4, and 51.1 g and lower (bulb and root) with 129.5, 135.8, and 127.7 g/plant. The three least-effective treatments were streptomycin sulfate, Kocide 101, and ammonium bicarbonate, which showed losses of 26%, 30%, and 36%. Fresh weights coincided at 30.5, 39.9, and 36.7 g/upper portion and 117.1, 116.5, and 113.1 g/lower portion, lightest of all treatments. The remaining four fungicides with streptomycin sulfate, in order of effectiveness at 16%, 16%, 18%, and 20% loss, were Consyst, Banrot, Medallion, and Heritage. When loss exceeded 20%, flower number/plant also declined. Because plant survival and vigor were not increased with trial chemicals, the common commercial pretreatment or no treatment at all is recommended. Continued research might reveal beneficial optimum rates for other chemicals.

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Resistance in *Impatiens wallerana* to Western Flower Thrips [*Frankliniella occidentalis* (Pergande)] Feeding Damage

B. Bejje Herrin* and Daniel F. Warnock; Univ. of Illinois, Dept. of Natural Resources and Environmental Science, 1201 S. Dorner Dr., Urbana, IL 61801

Western flower thrips are an ever-increasing problem in greenhouse floriculture crops. Thrips resistance to pesticides as well as tighter regulations on pesticide use are making thrips management in the greenhouse more difficult. To improve host plant resistance, a study was conducted to determine if *impatiens* cultivars varied in their susceptibility to western flower thrips feeding damage. In a replicated study, nine *impatiens* cultivars were inoculated with about 30 thrips. Thrips were allowed to feed on individual plants during an 8-week period of growth. During plant growth, visual evaluations to estimate thrips feeding damage were conducted every 2 weeks. At the conclusion of the experiment, a final visual evaluation was made and thrips numbers were determined. Cultivars varied in estimates of thrips feeding damage. Several cultivars exhibited significantly reduced levels of thrips feeding damage. Of these cultivars, some had high thrips population levels, indicating tolerance, while other cultivars had low thrips population levels, an indication of antibiosis. One cultivar was determined to be highly susceptible to thrips feeding damage. This cultivar was so damaged by the end of the study, remaining plant material was unable to support thrips populations. Variability was found in the levels of thrips feeding damage and thrips population levels indicating the presence of tolerance and/or antibiosis. Because of detected variability, the potential for improving *impatiens* resistance to thrips feeding damages exists.

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Forcing Requirements of Seed-propagated Easter Lilies

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

Seed-propagated lilies have the potential to revolutionize Easter lily production, eliminating clonal disease transmission, costly production and shipping.

Five F₁ interspecific hybrids, *Lilium* x *formolongo* (*L. longiflorum* x *L. formosanum*), were evaluated to establish an initial forcing schedule. The hybrids included 'Raizan Herald', 'Augusta F1', 'Raizan No. 1', 'Raizan No. 2', and 'Raizan No. 3'. Two hundred seeds/hybrid were sown in early July in plug trays. Ten weeks after sowing, seedlings were transplanted into 3-inch pots. At the 20-week stage, the seedlings were repotted into 6-inch standard pots for the final production phase. All hybrids had low germination rates (<20%). Hybrids were grown under two photoperiod treatments (short, long days) at 21 °C with n = 10 reps/hybrid/treatment. Plants were evaluated for no. days to visible bud, leaf unfolding rate, final plant height, leaf number, bud count, flowering dates, and the no. of shoots/bulb. Ten weeks after sowing, hybrids had one to four leaves/plant. At 20 weeks, the leaf number had increased to as many as 40. Despite the lack of a cold treatment, most hybrids initiated flower buds. Visible bud date occurred as early as 20 weeks after sowing. Photoperiod had no effect on leaf number, stem height, and flower bud initiation. Plant height exceeded 15 inches by week 16 in most hybrids, indicating the need for plant growth regulator applications. The next steps in product development for seed-propagated Easter lilies will be outlined.

445

Production of Castilleja as a Greenhouse Crop in Wyoming

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The objective of this study was to determine if hemiparasitic *Castilleja* (Indian Paintbrush) could be successfully sown and grown in the same containers with each of three host plants. Perennial *Castilleja linariifolia*, Wyoming's state flower, was sown in combination with either *Helianthus annuus* 'Pacino', *Lupinus* 'Russell Mix', or *Artemisia frigida*. Seeds were sown 7 Oct. 1999 in 128-cell plug trays. Trays were then placed on a mist propagation bench at 21 °C until emergence of any plant species was evident. *Artemisia* emerged 12 Oct.; *Lupinus* and *Helianthus* emerged 13 Oct. Plug trays were then transferred to a greenhouse at 13 °C night/21 °C day temperatures under natural light conditions. Plugs were transplanted into 11.4-cm-diameter containers on the following dates: *C. linariifolia*/*Helianthus*—12 Nov.; *C. linariifolia*/*Lupinus*—18 Nov.; and *C. linariifolia*/*Artemisia*—2 Dec. *C. linariifolia* emerged, after transplanting, on 16 Dec. All three combinations were successfully produced in the greenhouse.

446

Potted Sunflowers: Production and Postharvest Study

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Days from sowing to anthesis were significantly different among six sunflower (*Helianthus annuus* L.) cultivars and ranged from 52 days for 'Big Smile' to 87 days for 'Pacino'. Height ranged from 13.5 cm for 'Big Smile' to 37.3 cm for 'Pacino'. Postproduction life ranged from 10 days for 'Pacino' and 'Elf' to 15 days for 'Big Smile'. Postproduction quality ratings (1 to 5, with 5 the best) ranged from 3.9 to 5 after 5 days and 1 to 4.2 after 10 days. Quality ratings after 15 days were not significantly different among cultivars, because few plants were marketable at 15 days. Increasing the number of plants per pot from one to three or five reduced number of days to anthesis and postproduction life. Pot sizes of 10-, 13-, or 15-cm diameter, had no influence on production or postproduction characteristics. Promalin (62.5 to 500.0 mg·L⁻¹) was not commercially useful in extending postproduction life. Two cultivars were found to be most suitable for pot production, 'Pacino' and 'Teddy Bear', with one plant per 15-cm pot and sprayed with B-Nine at 8000 mg·L⁻¹.

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Predicting Development of *Lilium* (Asiatic Hybrid) using Thermal Units

J. Steinger and C. Pasian*; Dept. of Horticulture and Crop Science, The Ohio State Univ., Columbus, OH 43210.

The objective was to develop a Thermal Units model to be used as a timing tool for two cultivars of Asiatic lilies: 'Butter Pixie' and 'Horizon'. Two-hundred-eighty-six plants of each cultivar were evaluated over a 2.5-year period. Environmental data were collected using thermocouples and data-loggers. Developmental events observed daily were: shoot visible out of the soil (VS), visible flower bud (VB), and open flower (OF). Rates of development (the inverse of the numbers of days to complete a given phenophase) increased with temperature up to a

point. Thereafter, as temperature continued to increase, rate of development either slowed or declined. A piece-wise linear regression change point model was fitted to each data-set using S+ statistical package. This allowed the determination of the base temperature (T_b), optimal temperature (T_o), and the point of inflection (T_i). Tbs for the phenophase VS:OF of 'Butter Pixie' and 'Horizon' were -0.4 °C and 3.0 °C, respectively. The resulting discontinuity of data prompted improvements in the thermal unit calculation formula. Using the new formula, thermal units were calculated. $1,102$ °Cd and 833 °Cd had to be accumulated to complete the phenophase VS:OF for 'Butter Pixie' and 'Horizon', respectively. Predicted date of events were calculated and compared with the observed values. Subdividing the phenophase VS:OF into two (VS:VB and VB:OF) and using their respective Tbs and thermal units requirements reduced the error of prediction to 1.87 d from 2.13 d for 'Butter Pixie' and to 1.86 d from 2.39 d for 'Horizon'.

448

Cutting the Main Stem of Sunn Hemp Plants Increased Flower Production

A.A. Abdul-Baki^{*1}, H.H. Bryar², G.M. Zinati², W. Klassen², M. Codallo², and N. Hecker²; ¹U.S. Dept. of Agriculture, BARC, Beltsville, MD 20705; ²Univ. of Florida, IFAS, Tropical Research and Education Center, 18905 SW 280 St., Homestead FL 33031

Prolific flowering is essential for economic seed production in sunn hemp (*Crotalaria juncea* L.). Since flowers appear as racemes on the distal portions of secondary branches and since the branching is restricted by a strong apical dominance, lifting the apical dominance by cutting the tops of plants should induce more branches and more flowers per plant. We evaluated this concept in a field experiment conducted in 1999 at the Tropical Research and Education Center, Univ. of Florida, Homestead, by cutting main stems of 100-day-old plants in a dense stand (113,000 plants/ha) at 30, 60, and 90 cm above the soil surface. Cutting at all heights induced more branching and flowering than the control. The highest positive response was in plants in which the main stem was cut at 90 cm above soil surface.

31 ORAL SESSION 4 (Abstr. 449–455) Vegetable Crops: Crop Production Monday, 24 July, 10:00–11:45 a.m

449

Cucurbit Viruses in Southern Illinois

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Cucurbit viruses are a major hindrance to cucurbit production in southern Illinois, often rendering cucumber and summer squash fruit unmarketable. Specific viruses infecting cucurbits in the region need to be determined since this would enable growers to make better decisions on virus disease management. Leaf samples of various cucurbit vegetables that had symptoms of viral infection were collected from grower fields during the 1998 and 1999 growing seasons to determine the predominant cucurbit viruses present. Samples were assayed for the presence of five individual viruses: cucumber mosaic virus (CMV), papaya ringspot virus (PRSV, formerly watermelon mosaic virus-1), squash mosaic virus (SqMV), watermelon mosaic virus (WMV, formerly watermelon mosaic virus-2), and zucchini yellow mosaic virus (ZYMV). Results from the two years indicated that WMV was the most prevalent virus in southern Illinois. Cucumber mosaic virus was found both years, but only in a low percentage of samples collected each year. Two cucurbit viruses, PRSV and ZYMV, were each identified only in one sample during the 1998 growing season, and neither were found in any of the samples collected during 1999. Squash mosaic virus was not identified in any of the samples collected during 1998; however, for the 1999 growing season, SqMV was identified in 19% of the samples collected, primarily from those samples of transgenic squash that were showing symptoms of virus infection.

450

Effects of Transplant Production and Handling Practices on Processing Tomato Production

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Three field trials were conducted in central California in 1999 to assess the effects of transplant production and handling practices on yield, crop maturity, and fruit quality of processing tomato (*Lycopersicon esculentum* Mill.). For each trial, transplants of 'Halley' tomato were obtained from a variety of commercial greenhouse transplant growers and subjected to various conditioning treatments during the week prior to planting. These treatments included N and/or P fertilization, varying temperature exposure or degree of water stress, or storage in the dark for 2 days before transplanting to simulate shipment from greenhouse to field. Nine transplant treatments (combinations of transplant source and conditioning treatment) were evaluated in each trial, with five 30 m long single-row plots per treatment arranged in a randomized complete-block design. Plots were mechanically harvested. Despite large differences among treatments in initial transplant characteristics (plant height, root cell volume, macronutrient content), there were no significant treatment differences in fruit yield in two trials; in the third trial, one treatment had significantly lower yield than the highest yielding treatment. In no trial were treatment differences in crop maturity (percent green fruit) or fruit quality (soluble solids content or juice color) significant. Across trials, the only transplant characteristic positively correlated with relative fruit yield (treatment yield/mean yield of that trial) was shoot P concentration, which varied among treatments from 1.3 to 11.7 g·kg⁻¹.

451

Transplant Depth can Overcome "Elephant's Foot" Disorder in a Hydroponic Greenhouse Sweet Pepper Crop

Elio Jovicich^{*} and Daniel J. Cantliffe; Horticultural Sciences Dept., Univ. of Florida, 1251 Fifield Hall, PO Box 110690, Gainesville, FL 32611-0690, USA

A physiological disorder, "Elephant's Foot", can develop in greenhouse hydroponic sweet pepper (*Capsicum annum* L.). In a plant with this disorder, the base of the stem becomes swollen below the cotyledon level and wounds develop at the base of the stem's epidermis, what might predispose it to a localized rot and result in a sudden permanent plant wilt. Salt accumulation at the base of the stem could be a possible cause of the epidermis wounds. The effects of soilless media type (perlite, coconut coir, pine bark, and peat-perlite-vermiculate mix), transplant depth, and amount of nutrient solution applied per day were studied to evaluate the development of "Elephant's Foot" on a summer-fall sweet pepper greenhouse crop in Gainesville, Fla. Seedlings grown in polyethylene containers were transplanted 29 June 1999 into 11.4-L pots at three transplant depths: a) at half of the cell height, discarding only the bottom of the container (TOP); b) at the cotyledon level (LEVEL), and c) at the second stem node (DEEP). Plants were irrigated with 2, 2.5, 3, 3.5, and 4 L/day per plant of solution. The percentage of plants with epidermis wounds at the base of the stem was highest (82.5%) on TOP plants, compared to LEVEL (5.8%) and DEEP plants (0%). TOP plants had higher values of electrical conductivity on the stem epidermis than LEVEL and DEEP plants. There was a positive linear relationship ($r = 0.82$) between the percentage of plants with epidermis wounds and the electrical conductivity. Early yield of extra large and large fruits was higher in DEEP (1.05 kg·m⁻²) than in TOP plants (0.82 kg·m⁻²). Transplanting sweet pepper with the cotyledonary node under the soilless media could minimize salt accumulation and epidermis damage at the base of the stem level.

452

Stand Reduction and Foliage Damage Reduce Yield of Onion for Dehydration

George H. Clough^{*}; Dept. of Horticulture, Oregon State University, Hermiston Agricultural Research & Extension Center PO Box 105, Hermiston, OR 97838

Field trials were conducted at Hermiston, Ore., from 1995 through 1998 to determine the impact of stand loss and plant damage at different growth stages on yield of onions grown for dehydration. The experiment was a complete factorial with four replications. Stand reduction (0%, 20%, 40%, 60%, 80%) and foliage damage (0%, 25%, 50%, 75%, or 100%) treatments were applied at 3-, 6-, 9-, and 12-leaf onion growth stages. All average onion production characteristics decreased linearly as stand reduction increased (plant population decreased) at all plant growth stages except average bulb weight which increased as stand was reduced. Bulb weight was not changed by up to 100% foliage removal at the

three-leaf stage of growth. At the 6- and 12-leaf stages, bulb weight was reduced when >50% of the foliage was removed. The most severe response occurred at the nine-leaf stage when bulb weights were reduced the most. At the three-leaf stage, yield was not affected by foliage damage. At the six-leaf growth stage, yield was reduced by 75% or more foliage loss, but at the 9- and 12-leaf stages, >50% foliage removal reduced expected yields. As with bulb weight, the impact of foliage removal on yield was most severe at the nine-leaf growth stage.

453

Evaluation of a Phosphate-charged Soil Material as a Source of Phosphorus for Soilless Root Media

*Young-Mi Oh*¹, *Paul V. Nelson*¹, and *Dean L. Hesterberg*²; Departments of ¹Horticultural Science and ²Soil Science, North Carolina State University, Raleigh, NC 27695

A soil material high in metal oxides collected from the Bw horizon of a Hemcross soil in the state of Oregon was charged with phosphate, added to a soilless root medium, and evaluated for its potential to supply phosphate at a low, stable concentration during 14 weeks of tomato cropping (three successive crops). Three rates of phosphate were charged on the soil material, 0, 2.2, and 6.5 m P/g soil material and the soil material was incorporated into a 3 peatmoss : 1 perlite (v:v) medium at 5% (40 g) and 10% (80 g) of the volume of a 13.6-cm pot (1.0 L of medium). Uncharged soil material incorporated into soilless root medium at 5% and 10% reduced soil solution phosphate to deficient levels for 2 and 7 weeks, respectively. Phosphate was adequately supplied for 7, 10, 12, and more than 14 weeks in the 2.2P-5%, 2.2P-10%, 6.5P-5%, and 6.5P-10% treatment, respectively, as determined by symptoms of P deficiency. Phosphate and K levels in soil solution were highest at the beginning of crop 1 and tended to decline thereafter. Incorporation of soil material into soilless root medium improved pH stability whether it was charged with phosphate or not. The loss of the phosphate-charged soil material was negligible, 0.3% for the 6.5P-5% treatment and 1.2% for the 6.5P-10% treatment. The minimum critical concentration of soil solution phosphate for tomato in a 3 peatmoss : 1 perlite (v:v) medium as determined by the pour-through extraction procedure was found to be 0.3 mg·L⁻¹ or slightly less.

454

Effect of Tuber Cutting and Planting Dates on Growth and Yield of Some Potato Cultivars

M.M.A. Abdalla^{*}, *A.M.A. Butt*, *A.M.El-Damarany*, and *S.M.A. Mckhaiel*; Dept. of Horticulture, Faculty of Agriculture, Assiut Univ., Assiut, Egypt

This work was performed at the Experimental Farm of the Faculty of Agriculture Assiut Univ. during two fall seasons (1995–1996 and 1996–1997) to study the effect of planting date, cultivar, and seed cutting on the growth and yield of potato. A factorial experiment was designed. All data was subjected to statistical analysis. The results indicate that there is a significant effect for all the studied factors on the growth and yield of potato. The data also indicate that planting on 1 Oct. or 1 Nov. showed higher emergence percentage, total yield, final plant stand, rate of emergence, and height and number of stems. 'Spunta' produced the highest stem length, fresh weight per plant, and total yield. Whole tubers gave higher stem length, plant fresh weight, tuber weight, and tuber number per hill.

455

Yield and Yield Attributes of Onion Cultivars Grown in Arid Regions

Abdullah A. Alsadon^{*}; Department of Plant Production, College of Agriculture, King Saud University, Riyadh 11451, Saudi Arabia

Eleven onion (*Allium cepa* L.) cultivars were selected to evaluate their yield performance under the arid conditions of the Riyadh area in the Central region of Saudi Arabia during the 1996–97 and 1997–98 growing seasons. The selected cultivars were: Colossal PVP 234, Contessa, Dorado, Red Creole, Ring Master, Rio Sultan, RioTalat, Texas Grano 502, Texas Early Grano 502, Und Grande and Yellow Spanish. Yield (ton/ha) and yield attributes such as bulb diameter, length, weight and dry matter were assessed. Transplants grown in plastic trays for 45 days under greenhouse conditions were transplanted in the field on 7 Jan. 1997 and on 29 Dec. 1997 and harvesting was carried out on 19 May 1997 and on 15 May 1998 for the first and second season, respectively. Significant differences were observed between cultivars and among growing seasons, with significant interaction for yield and bulb weight. The top high yielding cultivars in the first season were Und Grande, Texas Early Grano 502, Colossal PVP 234, Contessa

and Dorado. In the second season, Dorado, Red Creole, Contessa, Ring Master and Und Grande outyielded other cultivars. Under the conditions of this study, Contessa, Dorado, Red Creole, Texas Early Grano 502, and Und Grande had the highest yield attributes that made them recommended for growing in the arid regions. The yield and yield attributes of each cultivar will be discussed.

32 ORAL SESSION 5 (Abstr. 456–463)

Cross-commodity: Education

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

456

Measuring the Intensity of School Gardening Programs and the Impact on Positive Youth Development

S.M. Skelly^{*} and *J.C. Bradley*; Dept. of Environmental Horticulture, University of Florida, Gainesville, FL 32611-0670

The number of school garden programs in America is growing. With interest in school gardens rising, research exploring the benefits of school gardens is important to establish the value of horticulture and gardening in primary education to help schools develop, promote, and use gardens for a variety of purposes. The goals of this research project were 1) to develop a typology, or matrix, of school garden program intensity and 2) to determine if variables related to positive youth development varied within the intensity typology. Twenty elementary schools in Florida participated in the research project accounting for ≈20 teachers and 400 third-grade students. This presentation will include how the typology was developed using three levels of intensity (high, medium, and low) and three types of gardens (vegetable, flower, and combination). The dependent variables examined for this study were the student developmental assets of responsibility, school engagement, achievement motivation, and interpersonal competence. Additional dependent variables included students' environmental attitudes and attitudes toward science. Discussion of school garden program intensity and the influence it may have on positive youth development will be the focus of this presentation.

457

Postharvest Research and Training: A Powerful Development Tool in Developing Countries

Rufino Perez-Brennan^{*}; Postharvest/Processing-Food Safety, EU-CARIFORUM Caribbean Agriculture & Fisheries Programme, 1 Dere St. 11, Port of Spain, Trinidad & Tobago, West Indies

During the past 30 years, numerous studies undertaken in developing countries, such as the region of the Caribbean, have consistently demonstrated that the returns on agricultural research investments are superior to any other alternate use of resources in agriculture. It has been reported that investment in agricultural research has contributed to an increase in productivity of ≈40% in pilot areas. In spite of this figure, countries such as those in the Caribbean region still do not consider research as a development tool that could be used to solve problems such as postharvest losses of perishable crops. During the past decade, international cooperation organizations have been supporting research and training activities to help developing countries to be able to compete economically and access international markets. The main idea of these cooperation programs is to make agribusinesses understand that investing in research and training activities in areas such as postharvest and food distribution is one of the most powerful development tools that would help these countries to access better and more markets. It is hard to see a continuous and progressive increase in productivity and competitiveness without the corresponding technological development that would make products fulfill international standards.

458

Professional Development for Graduate Students: A Course Offering at the University of Florida

S.M. Skelly^{*}, *T.C. Kohlleppe*, *M.E. Kane*, and *J.C. Bradley*; Dept. of Environmental Horticulture, University of Florida, Gainesville, FL 32611-0670

In Spring 1999, the Environmental Horticulture Graduate Student Association (EHGSA) at the Univ. of Florida was given the opportunity to develop a professional development course, for credit, for graduate students. Members of the EHGSA determined that there was a need for seminars on topics such as curricu-

lum vitae development, interview techniques, effective presentations, successful teaching, and many more topics pertinent to the graduate student as a future professional both inside and outside of academia. As a group, the EHGA determined the seminar topics, found speakers to present the information and organized the course for the Fall 1999 semester. The rationale for creating this course, its development, topic selection, and student reviews will be presented.

459

New Ideas for Recruiting Horticultural Undergraduate Students

*Norman F. Childers**; Univ. of Florida, Gainesville 32611

For about 65 years, I have tried many ideas for recruiting horticultural students. Each has been effective to a limited extent, often involving much time in contacting vocational-agricultural schools and high school career advisors, making movies and slides, printing and distributing brochures, and designing and distributing displays at meetings. These continuing efforts are worthwhile and needed; however, I have found it easier, perhaps less expensive, and more effective, to recruit students already on campus. On college campuses, there are always a wealth of students still undecided on a major or minor, even in their senior year. The problem is to find a way to attract these students to stimulating experiences in horticulture and, at the same time, gain administrative credit for more undergraduates in departmental classes. Since 1990, the Univ. of Florida has been offering a 1-h credit "snack" course titled "Growing Fruits for Fun and Profit" at the noon hour two days a week in the spring and summer semesters. We serve the students a few fresh strawberries in that fruit is the topic, a big cookie or two, and a fruit drink. Enrollment has grown to a limited 300 students in spring and 80 students in summers—with a waiting list! We cover most fruits grown in Florida, with help of extension personnel specializing in the respective fruit and with the leader (Rebecca Darnell or me) offering a few of the 15 lectures. One session is a tour of the Univ. of Florida fruit plantings. Students are required to be present (given one absence) and keep a notebook. There are no exams. Students are graded on their attendance, notebooks, and attentiveness. One lecture from vegetables or ornamental faculty may be invited during the course. Most students get an A or B. For further attraction, 12 to 15 scholarships of \$500 to \$1500 are offered. We have been able to capture a few majors each year from students coming from across the campus.

460

Using Critical Thinking Exercises to Increase Environmental Awareness of Undergraduate Horticulture Students

*Milton E. Tignor**¹ and *Sandra B. Wilson**²; ¹Horticultural Sciences Department, ²Department of Environmental Horticulture, Indian River Research and Education Center, Institute of Food and Agricultural Sciences, University of Florida, Fort Pierce, FL 34945-3138

Information is more accessible to students than ever before. Gone are the days of a single instructor being the ultimate authority on a specific scientific discipline. Search engines, online journals, virtual libraries, and the development of Internet II will continue to drive the increase in availability of information. With basic computer skills, the average college student can put their hands on more subject data than they could possibly read during the time frame of a semester-long course. Therefore, it is more critical than ever to give students the logical tools to evaluate information and construct intelligent arguments. One particular area of interest to the horticulture industry is the impact of environmental regulations and public concern over common horticultural production practices such as irrigation, land development, application of pesticides, and developmental manipulation using growth regulators. South Florida is a mosaic of pristine natural areas, major agricultural production regions, densely populated urban areas, and regions of rapid suburban growth. As a result, there is heightened public awareness of environmental issues, which often leads to spirited conflicts among people with diverse professional backgrounds and personal interests. This catalyzed the development of a new course entitled "South Florida Flora and Ecosystems" that uses several different types of critical thinking exercises to help relate course content information into the cultural and political framework of South Florida. Techniques such as role playing, utilizing guest speakers with opposite opinions on the same topic, and active evaluation of data were used to enhance student learning, increase environmental awareness, and place undergraduate horticultural students one step closer to becoming "society-ready" graduates.

461

Multimedia Dissemination On and Off Campus of Two Landscape Horticulture Courses

*Roger Kjelgren** and *Larry Rupp*; Dept. Plants, Soils, and Biometeorology, Utah State Univ., Logan, UT 84322

We developed two courses, sustainable landscaping and landscape water conservation, to meet time-constrained students on campus and place-bound students off campus. Lecture material consisting of text, slides, drawings, and some video were assembled digitally using presentation software. Each course was broken into nine to 10 units by topic matter, and each unit consisted of 50 to 100 individual "slides" containing visuals, text, and audio narration. The lecture material was then packaged for student consumption onto videotape and CD-ROM, and on the Web (without audio) and as hard copy. Students taking the course received a course reader of the lecture material in hard copy and CD format. Contact with the instructor was through e-mail and a threaded newsgroup on the Web. All testing was with take-home quizzes and an exam. These courses had 700 to 800 slides averaging 1 min of narration per slide, equaling 12 to 14 h of audio. Assembly time for 1 h of narration, or about 60 slides, was 20 to 30 h. These courses are taught live in a classroom, where the presentation time is doubled compared to audio narration, alternate years, and have been available every term on an arranged basis. Survey results of 40 students to date taking the course on an arranged basis, obtaining lecture material mainly through CD-ROM, showed that by a 6:1 margin, their learning experience was overall positive. However, by a 19:1 margin, students would have preferred to have taken the course with live classroom instruction. Developing digital courses such as these is only feasible if a faculty member has unequivocal and ample administrative and financial support, and is only cost-effective if there is sufficient student demand outside of conventional scheduling.

462

Nursery Management Offered Via Videotape for Place-bound Students

*Robert R. Tripepi**; Plant Science Division, University of Idaho, Moscow, ID 83844-2339

Nursery management, a course covering practices involved in production of woody landscape plants, was developed for delivery to place-bound students at distant sites around the state. Course subject matter was divided into 41 modules and involved aspects of site selection, cost accounting, plant propagation, nursery trade associations, licensing, as well as container and field production practices. Each module began and ended with a 1- to 2-min introduction and summary to the subject matter, and these segments were taped on location at nurseries in the Pacific Northwest. The lecture portion of each module was taped in a multimedia classroom, and presentation software was used to present text, slides, drawings and animation. Videotape footage of some cultural practices was also inserted into lectures as a "field trip." Students in the course also received a lecture note guide for all modules in the course. In Idaho, the videotapes were distributed to education centers around the state. The first time the course was offered, 11 students at distant sites and three time-constrained students on campus enrolled. Students contacted the instructor by phone or e-mail. Homework assignments were sent via FAX or e-mail attachments, and tests were sent to the education centers where proctors gave three exams and a final exam. All tests and homework assignments were graded by the instructor located on campus. A videotaped course in nursery management can adequately convey principles involved in landscape plant production, but logistics of mailing videotapes and grading assignments and tests should be carefully evaluated when deciding if a course should be offered at a distance.

463

Keeping in Touch While Studying Abroad

*Tim Rhodus**; Department of Horticulture & Crop Science, The Ohio State Univ., Columbus, OH 43210

Study Abroad programs are designed to provide a variety of learning opportunities for students. Experiencing firsthand the culture, environment, and/or industry is often described as the most memorable benefit by those who study for a quarter or semester in another country. Unfortunately, it is difficult to share this learning experience with classmates and family members who are back at home. One solution that has been implemented with the College's Study Abroad program at The Ohio State Univ., is to design a web site that chronicles the experiences and activities of students while they are abroad. In addition to the photos

and stories being contributed from abroad, classmates and other individuals from the home institution can submit questions and participate in threaded discussions with those abroad. For example, students at home can post questions regarding an upcoming tour location and utilize the responses and photos for a class they are attending. Finally, being able to review experiences from previous trips is an outstanding strategy for promoting the program to new students. Online experiences from the Dominican Republic and England programs are available at: <http://cfaes.ohio-state.edu/studyabroad>.

33 ORAL SESSION 6 (Abstr. 464–471) Cross-commodity: Genetics/Breeding/ Biotechnology Monday, 24 July, 10:00 a.m.–12:00 noon

464 The Biochemical Basis for Purple, Blue and Red Flower Colors in Calibrachoa LaLlave & Lexarza

R.J. Griesbach* and R.A. Waterworth; Floral and Nursery Plants Research, U.S. National Arboretum, USDA, ARS, BARC-W, BLDG 010-A, Beltsville, MD 20705-2350

Recently, several new Calibrachoa La Llave & Lexarza cultivars have been developed with novel red and blue flowers. Most of the wild species of Calibrachoa have purple flowers. The difference in color between the red, blue, and purple flowers was not due to anthocyanin composition but to vacuolar pH. The pH of the red flowered cultivar was 4.8, while that of the blue flowered cultivar was 5.6. The wild purple flower species had an intermediate pH of 5.0. The difference in pH was genetically inherited.

465 Carotenoid and Anthocyanin Content in High Pigment and Heirloom Tomato Germplasm as Measured by a Rapid HPLC Method

Carl M. Jones* and James R. Myers; Department of Horticulture, Oregon State University, ALS 4017, Corvallis, OR 97331

Continued and mounting evidence of the health benefits provided by carotenoid and anthocyanin pigments has increased public interest in dietary sources of these important phytonutrients. Tomatoes (*Lycopersicon esculentum*) are the primary dietary contributor of lycopene and an important source of beta-carotene. A collection of tomatoes containing the genes *hp-1*, *dg*, *ogc*, *lp*, *B* and *Af* that are known to affect carotenoid and anthocyanin levels have been analyzed using HPLC. Levels of lycopene, beta-carotene, phytoene, and phytofluene have been determined in these accessions. Accession LA 3005, containing the *dg* gene, had the highest lycopene levels of the accessions analyzed (14 mg/100 g fresh wt.). A rapid HPLC method for quantitation of carotenoid levels from tomato fruit has been developed. "Heirloom" black and purple tomatoes have also been included in the accessions analyzed and have carotenoid levels comparable to cultivated red tomatoes. Anthocyanin presence has been confirmed only in the accessions LA 1996 (*Af*) and in some fruit of segregating plants from LA 3668 (*Abg*). Total monomeric anthocyanin content of LA 1996 as measured by the pH differential method is estimated to be 5.6 mg/100 g in the outer pericarp tissues and 18.6 mg/100 g in the skin tissue.

466 The Reduced Pigment (*rp*) Gene and Biosynthesis of alpha- Tocopherol in Carrot Roots

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Carrots contribute ≈14% of the total Vitamin A to the human diet in the United States due to the presence of the provitamin A carotenoids α - and β -carotene. We have described a recessive gene (*rp*) that inhibits carotenoid biosynthesis in carrot by 93%, resulting in whitish-yellow roots. The *rp* mutation is also associated with relatively high levels of a tocopherol (Vitamin E, 0.61 ± 0.15 mg α -tocopherol/100 g FW). Vitamin E is a powerful antioxidant that must be obtained from the diet. The biosynthesis of a tocopherol in carrot has not been studied in

any detail; however, the *rp* gene may provide clues as to its mechanism. The production of carotenoids and tocopherols is biosynthetically linked by their common precursor, geranylgeranyl diphosphate (GGDP). GGDP is converted into phytoene by phytoene desaturase to produce carotenoids and combined with homogentisic acid to produce tocopherols. Carotenoid and tocopherol profiles for various carrot genotypes are presented alongside a model describing the potential relationship between root carotenoids and tocopherols in carrot. The presence of significant amounts of tocopherols in carrot could significantly raise the nutritional profile of this vegetable.

467 Mapping Anthocyanin Pathway Genes in Raspberry

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The role of plant pigments in human health has been under intense scrutiny recently. Anthocyanin pigments have been shown to be powerful antioxidants and may contribute to other areas of human health. In red and black raspberry, *Rubus idaeus* and *Rubus occidentalis*, respectively, no less than eight different anthocyanin pigments have been identified. However, the genetics controlling the presence and ratios of the different pigments is poorly understood. Various researchers have identified four loci that impart fruit pigment deficiencies and three loci that affect the pigment ratios. The underlying gene function of these loci is not known. Efforts are under way to map two pigment deficiency loci in red raspberry using bulked segregant analysis. Screening with 800 random primers has produced two markers with >90% and two with >80% correlation to one loci. For the other loci, 10 markers with >80% correlation have been identified. Mapping is ongoing with the first linkage map for raspberry to be presented. Populations to test allelism between sources of pigment deficiency are being evaluated for further mapping of loci of the anthocyanin production pathway. Data on cloning of genes in the anthocyanin pathway based on database sequences with degenerative primers for further elucidation a anthocyanin production in raspberry will be presented.

468 Inheritance of Day Neutrality and Heat-delay Insensitivity in *Dendranthema grandiflora* Tzvelj.

Neil O. Anderson* and Peter D. Ascher; Dept. of Horticultural Science, University of Minnesota, 1970 Folwell Ave., St. Paul, MN 55108

Greenhouse and garden chrysanthemums are quantitative short-day (SD) plants for flower bud initiation (FBI) and qualitative (obligate) SD plants for flower bud development (FBD). Continuous or intermittent application of red light in the middle of the dark period (night), inhibits FBI. The chrysanthemum breeding program has been selecting for day-neutral (DN) types, i.e. that will undergo FBI and FBD under any photoperiod. The inheritance of DN was studied using six cultivars ($n = 2$ SD types, $n = 4$ DN types) that were crossed in a complete diallel over two crossing periods. Pollinations were replicated and ovules were counted. Histograms of self and cross seed set showed a distribution from 0% to 100%, with the majority of pollinations below 30%. Mean self seed set (2.6%) was less than the mean cross seed set (32.8%), indicating the presence of a self incompatibility system. Parents and F_1 progeny were grown under LD conditions (red light, night interruption, 2200-0200 HR) and high temperatures (30 °C day/25 °C night, to screen for heat delay insensitivity). F_2 progeny could not be generated due to self incompatibility. The fraction of flowering : non-flowering progeny and the number of days to first flower was recorded on the flowering individuals for comparison with the parents. Due to small progeny numbers, reciprocal crosses were bulked prior to Chi-square tests (1:1, 3:1, 1:3). The number of days to first flower ranged from 27 to 93+ in all progeny with significantly earlier and later outliers present. Most Chi-square tests were not significant, indicating that the inheritance of DN and heat delay insensitivity are not controlled by a single gene. Additive and epistatic effects may also be present.

469 Multi-faceted Approaches to Genetic Engineering of *Petunia* *x hybrida* for Delayed Leaf Senescence

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In an effort to modify and study leaf senescence, we have produced several different transgenic petunia lines with altered leaf senescence phenotypes. Using two promoters from senescence-associated genes (*sag12* & *sag13*) fused to the

isopentenyl transferase (*IPT*) gene, which catalyzes the rate-limiting step of cytokinin production, we have produced transgenic petunia plants with delayed lower leaf senescence. We have observed that apparent "leaky" expression of *IPT* gives rise to plants with other morphological alterations such as increased branching habit and decreased root formation. Plants with delayed leaf senescence phenotypes were selected and bred to produce progeny that were evaluated in greenhouse experiments. Breeding characteristics, horticultural performance and reproduction of these plants will be discussed in terms of potential commercial benefits and limitations. Using the *sag12* promoter to drive expression of the *knotted* (*KN1*) gene, we have also been able to engineer petunia plants with delayed lower leaf senescence. Initial progeny evaluations of *sag12-KN1* petunias will also be discussed.

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Narrow-sense Heritability Estimates for Melon Root Traits

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Improving melon root systems by traditional breeding is one component of the program to develop multiple-stress-resistant melons at the Texas Agricultural Experiment Station, Weslaco. Ten diverse melon lines representing four horticultural groups were intercrossed utilizing a Design II mating scheme. The male parents were: 'PI 403994,' 'Perlita,' 'Doublon,' 'Caravelle,' and 'PI 525106.' The female parents were: 'Crème de Menthe,' 'Magnum 45,' 'BSK,' 'PI 124111 x TDI,' and 'Deltex.' F₁ progeny were grown in pasteurized sand in the greenhouse using a randomized complete-block design with four reps. After 4 weeks, root systems from all plants were carefully washed to remove the sand. Each root system was then placed onto a glass, plated, and scanned into the computer software Rhizo Pro 3.8 (Regent Instruments, Quebec). This software calculated root lengths of various diameter classes, root area, and root tip number. All data was input into Agrobase software for calculation of genetic variances based on Design II analysis. Significant differences of contributions by male parents to progeny variation were few. Only length of roots with 1.0- to 1.5-mm-diameter and vine length were significantly different. Differences in contributions by female parents to all traits except root tip number were highly significant. No significant interaction effects were observed for any trait. Narrow-sense heritability estimates were moderate to high for all traits. The range was from 0.56 for root tip number by males to 0.81 for both length of 0.5- to 1.0-mm-diameter roots and vine length for females. Estimates for total root length (0.76) and root surface area (0.77) were high. The lack of male by female interaction suggests very low dominance genetic variation and contributed to high heritability estimates, which represent predominantly additive gene action. Additive genetic variation allows more-efficient progress by selection, making the potential for root system improvement favorable.

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Defining the East African Highland Banana (I AAA) Ideotype and Breeding Objectives

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The East African highland bananas are a sub-group of the *Musa* AAA group and are unique to the mid-altitude and highlands of Eastern Africa. In much of the area where they are grown, highland bananas are the main staple crop for both rural and urban populations. Yields of highland bananas have fallen precipitously in many areas and production deficits have been met by shifting highland banana production into new areas. Yield reductions have been attributed to a number of factors, including plant parasitic nematodes, the banana weevil (*Cosmopolites sordidus*), and black Sigatoka leaf streak (*Mycosphaerella fijiensis*). A program to breed improved highland bananas was established at the International Institute of Tropical Agriculture's Eastern and Southern Africa Regional Center (IITA-ESARC) in collaboration with the National Banana Program of Uganda in 1994. Following preliminary studies of fertility, breeding began in 1997. The breeding program has taken as its model IITA's successful plantain-breeding program. The plantain-breeding program has used an ideotype breeding approach to selection of improved plantain hybrids. The unique features, culture, and end-use of highland bananas have necessitated the definition of a new ideotype. Results of studies during the past 2 years have identified traits unique to highland bananas and a highland banana ideotype has emerged.

49 ORAL SESSION 7 (Abstr. 472–479)

Fruits/Nuts: Crop Production/Physiology

Monday, 24 July, 2:00–4:00 p.m.

472

Effect of Pruning on Secondary Bloom in 'Bartlett' Pear

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Secondary bloom provides fireblight infection sites in pears (*Pyrus communis* L.) growing in the western U.S. Five types of secondary bloom occur in 'Bartlett', and one of these, Type V, occurs mainly as a result of pruning. We examined the effect of pruning dates (Feb. to Sept. 1999), shoot age ranging from 1 to 4 years old, and type of pruning cut (i.e., heading, stubbing, or thinning) on Type V secondary bloom. Pruning date was a significant factor determining whether Type V would occur. There was a greater chance for Type V to occur from pruning in February or March than for pruning from May through September. There was an increase in Type V with increase in shoot age when pruning 11 Feb., 17 Mar., 14 May, or 11 Aug. There was no shoot age effect when pruning 18 June or 30 Sept. Type of pruning cut affected the number of Type V that occurred when pruning 14 May, 18 June, or 11 Aug., but the effect of type of pruning cut was inconsistent between these dates. There was no effect of type of pruning cut when pruning 11 Feb., 17 Mar., or 30 Sept. These results indicate that summer or postharvest pruning may reduce the number of Type V secondary bloom, particularly on shoots older than one year. This information can be used to develop a pruning strategy that reduces the number of Type V secondary bloom and potentially the number of fireblight infection sites.

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Effect of Panicle Pruning and Bioregulators on Fruit Size in 'Kohala' Longan

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Panicles of 'Kohala' longan (*Dimocarpus longan* Lour.) trees often retain more than 250 fruit, which results in small fruit (<10 g) of reduced market value. During 1997 and 1998, we conducted experiments to increase fruit size in commercial groves. Trees flowered and fruited normally in 1997, but very scarcely and late in 1998. In 1997, treatments consisted of panicle pruning (clipping off half of the panicle) and/or removal of entire panicles (50% per tree) when young fruits were 5 or 10 mm in diameter. Control trees were left intact. The number of fruit per panicle varied greatly within trees. Panicles (pruned or intact) with <125 fruit generally developed fruit >15 g (32–33 mm equatorial diameter). Total soluble solid content of mature fruit generally decreased with increasing fruit size. Removing whole panicles did not increase average fruit size in remaining intact panicles, suggesting that panicles were fed primarily by leaves within the same branch. In 1998, treatments consisted of applications of GA₃ and/or CPPU (a synthetic cytokinin) when fruits were 6 to 9 mm in diameter. Panicles were not pruned since they generally had <150 fruit. Control panicles were not sprayed. There was no consistent effect of treatments on average fruit weight, and no treatment significantly increased fruit size in relation to controls. These preliminary results indicate that other factors besides current fruit set, such as previous fruit load of a branch, branch position (exposure to sunlight and/or wind, and proximity to major limbs), and the amount/age of leaves, may influence the fruiting potential of individual branches.

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High Application Rates of Reclaimed Water Benefit Citrus Growth and Production

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Citrus trees in an experimental planting responded well to high application rates of reclaimed water. Irrigation treatments included annual applications of 400 mm of well water and 400, 1250, and 2500 mm of reclaimed water. The effects of these irrigation treatments on two citrus cultivars ('Hamlin' orange and 'Orlando' tangelo) combined with four rootstocks were compared. Growth and

fruit production were better at the higher irrigation rates. The concentration of soluble solids in juice was diluted at the highest irrigation rate, but total soluble solids per hectare increased due to the greater fruit production. Average soluble solids/ha production was >15% higher at the 2500-mm rate than the 400-mm reclaimed water rate. While fruit soluble solids were usually lowered by higher irrigation, the reduction in fruit soluble solids observed on three of the rootstocks did not occur in trees on Carrizo citrange. Trees on Cleopatra mandarin grew similarly at the different irrigation rates, but canopy volume of trees on Swingle citrumelo was significantly smaller at the 400 mm rate than at the 2500 mm rate. Fruit peel color score was lower but juice color score was higher at the highest irrigation rate. Weed pressure increased with increasing irrigation rate, but was controllable. Both juice and fruit soluble solids were higher on Swingle citrumelo and lower on Cleopatra mandarin rootstock. Total soluble solids/ha, solids/acid ratio, and juice color were higher on Swingle rootstock. Reclaimed water, once believed to be a disposal problem in Florida, can be an acceptable source of irrigation water for citrus on well drained soils at rates up to twice the annual rainfall.

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Performance of *Koeleria macrantha* (Ledeb.) J.A. Schultes 'Barkoel' and Low Maintenance Turfgrass Species for Orchard Floor Management

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Various turfgrass species and cultivars are utilized for orchard floor management. Selection and establishment of low-maintenance species compatible with site conditions results in less need for mowing, fertilizing, and pesticide applications. *Koeleria macrantha* (Ledeb.) J.A. Schultes is a new turfgrass species that has demonstrated outstanding low-maintenance characteristics. This study evaluated the only commercially available cultivar 'Barkoel' and three other species, including *Festuca arundinacea* Schreb (tall fescue), *Festuca rubra* L. ssp. *falax* Thuill (chewings fescue), and *Festuca longifolia* auct. non Thuill (hard fescue). Turf was seeded in a commercial peach orchard in Oct. 1996 and evaluated through Oct. 1999. After 3 years, the hard fescue cultivars had the best quality, with excellent density and low weed populations. Chewings fescue also had good density and few weeds. Tall fescue had good density, but more weeds than the hard and chewings fescues. *Koeleria macrantha* 'Barkoel' had unacceptable quality, with poor density and the highest weed populations. The fine fescues, hard and chewings, suffered damage from orchard maintenance equipment. Damage was most severe during heat and drought stress in Summer 1999. Growers should limit equipment traffic on hard and chewings fescues during heat and drought stress. Tall fescue showed no significant damage from equipment, but it demonstrated a faster vertical growth rate. This increases the need for mowing. *Koeleria macrantha* 'Barkoel' was not damaged by equipment. While *Koeleria* had the least density and most weeds after 3 years, it has performed well in our other tests. Higher seeding rates or modifications in seedbed preparation may improve density and reduce weed infestations.

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Reducing Midday Irradiance Increases Net CO₂ Assimilation in Citrus Leaves

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Maximum CO₂ assimilation rates (ACO₂) in citrus are not realized in environments with high irradiance, high temperatures, and high leaf-to-air vapor pressure differences (D). We hypothesized that moderate shading would reduce leaf temperature and D, thereby increasing stomatal conductance (g_s) and ACO₂. A 61% reduction in irradiance under aluminum net shade screens reduced midday leaf temperatures by 8 °C and D by 62%. This effect was prominent on clear days when average midday air temperature and vapor pressure deficits exceeded 30 °C and 3 kPa. ACO₂ and g_s increased 42% and 104%, respectively, in response to shading. Although shaded leaves had higher g_s, their transpiration rates were only 7% higher and not significantly different from sunlit leaves. Leaf water use efficiency (WUE) was significantly improved in shaded leaves (39%) compared to sunlit leaves due to the increase in ACO₂. Early in the morning and late afternoon when irradiance and air temperatures were low, shading had no beneficial effect on ACO₂ or other gas exchange characteristics. On cloudy days or when the maximum daytime temperature and atmospheric vapor pressure deficits were less

than 30 °C and 2 kPa, respectively, shading had little effect on leaf gas exchange properties. The results are consistent with the hypothesis that the beneficial effect of radiation load reduction on ACO₂ is related to improved stomatal conductance in response to lowered D.

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Sources of Supplemental Pollen and Their Contribution to Yield in Almonds

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Almond flowers are self-incompatible and require cross-pollination for nut set. Commercial production requires pollinizers be planted within an orchard and the presence of honeybee colonies during bloom. External pollen sources are also available when "nearby" orchards produce flowers simultaneously, and when growers apply "extra" precollected pollen to foragers. The latter cultural practice is performed to improve cross-pollination under adverse bloom conditions. Paternity tests on nuts detected these two sources of supplemental pollen and measured what percent (%) each contributed to fertilization and crop production. Polymorphic enzymes were analyzed following electrophoresis of extracts from 42,000 embryos sampled over an 8-year period from orchards throughout California. A J-shaped frequency histogram was produced by "nearby" pollen sources (n = 30), with 0% to 0.2% being the most common class. The histogram from "extra" pollen (n = 70) was strongly right-skewed and bimodal (m¹ = 2.0% to 2.5%, m² = 15.0% to 17.5%). Both sample populations possessed significantly different (P < 0.001) means, medians, and variances. Nut production by pollen from nearby orchards ranged from 0% to 5% (mean 0.97%, median, 0.45%, SD = 1.455); and production by extra pollen applied to honey bees ranged from 0% to 55% (mean 12.51%, median 7.9%, SD = 12.09). Evidence suggests pollen applied to honeybees contributed from 13- to 18-times more to yield than pollen transferred, naturally, from orchard to orchard.

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Characteristics of Fruit Flesh Pithiness Symptoms in 'Yumyeong' Peach [*Prunus persica* (L.) Batsch]

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'Yumyeong' peach has the desirable characteristics of long shelf-life and specific non-melting nature with a long harvest period. However, some fruits harvested too late show fruit pithiness symptoms or internal breakdown. This study was conducted to analyze the differences between fruit flesh pithiness and internal breakdown symptoms and to find out the source of flesh pithiness in 'Yumyeong' peach. The rate of flesh pithiness was higher in fruit harvested late in the season. Sugar and malic acid contents showed no differences between the normal and flesh pithiness fruits, but the acidity was significantly lower and was affected by low citric acid content in flesh pithiness fruit. In flesh pithiness fruits, calcium contents were low both in skin and flesh. Occurrence of flesh pithiness fruits was high in the years with low precipitation and high temperature for 2 months before harvest. In observations on morphological characteristics, the parts showing flesh pithiness consisted of smaller cells than the normal parts. Tonoplasts disintegrated and the number of dead cells was high in internal breakdown fruits, while the tonoplasts were intact, with contracted vacuoles, in flesh pithiness fruits. Tylosises were observed in vascular tissues around the flesh pithiness; therefore, it was assumed that those tylosises restrict flesh tissue development, resulting in flesh pithiness. Other varieties ('Fantasia', 'Wolmi' and 'Hakuto') also showed tylosis, and smaller cells were observed in the flesh tissue of these cultivars, indicating abnormal growth of the flesh part. These results suggest the possibility of the occurrence of pithiness-like symptoms in other peach varieties.

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Fruit Characteristics and Productivity of Date Palm Trees (*Phoenix dactylifera* L.) as Affected by Some Growth Regulators

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Date palm trees are among the most plentiful fruit trees in the Arabian Gulf States. Bioregulators have been used for the improvement of quality and productivity of date palm tree fruits. Application of gibberellic acid (GA₃), naphthalene acetic acid (NAA), and ethephon, separately or in a mixture, has significant effects on fruit set, fruit dry matter percentage, fruit soluble percentage, fruit ripen-

ing, and yield of date palm trees. A study was conducted to assess relative effectiveness of GA₃, NAA, ethephon, and a mixture of growth regulators on some fruit characteristics, and productivity of 'Barhee' date palm trees. Five uniform female 'Barhee' date palm trees were pollinated on 5–15 Mar. 1994, 1995, and 1996 by placing eight fresh male strands on female spadix centers (flower cluster). Ten flower clusters were used on each tree, and every two flower clusters were subjected to one of the following treatments: control (water), 150 mg·L⁻¹ GA₃, 100 mg·L⁻¹ NAA, 1000 mg·L⁻¹ ethephon, and a mixture of growth regulators. The fruit set (%), dry matter (%), total soluble solids (°Brix), fruit ripening (%), and fruit weight (kg per bunch and per tree) were measured. The data showed that the application of GA₃ or ethephon on flower clusters of 'Barhee' date palm trees had no constant effect on fruit characteristics and productivity of trees. NAA or a mixture of growth regulators reduced fruit dry matter percentage, fruit ripening percentage, and increased fruit weight per bunch and per tree. Spraying 'Barhee' date palm flower clusters with NAA or a mixture of growth regulators 20 days after pollination decreased dry matter percentage, fruit ripening, and increased fruit flesh percentage and tree yield.

50 ORAL SESSION 8 (Abstr. 480–486)

Fruits/Nuts: Genetics/Breeding/ Biotechnology

Monday, 24 July, 2:00–3:45 p.m

480 Screening for Fire Blight Resistance in Apple Rootstock Breeding

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A primary focus of the apple rootstock breeding and evaluation program at USDA-ARS/Cornell Univ. has been to develop screening protocols to identify genotypes resistant to the fire blight bacterium (*Erwinia amylovora*). Direct inoculation is a simple technique, but does not represent the only mode by which rootstocks become infected in the orchard. Selection based on direct inoculation screens may, however, enrich the population for resistant genotypes. Large breeding populations from controlled crosses are shoot-tip inoculated with *E. amylovora*, and the fraction showing the highest levels of resistance are retained for further evaluations. These survivors are again screened through direct inoculation in the field, and the less-resistant genotypes are discarded. Following selection for other pathogen tolerance and horticultural characters, elite genotypes are multiplied through asexual propagation. Replicated tests using direct inoculation with multiple strains of *E. amylovora* are then used to estimate the level of fire blight resistance of elite genotypes. A final screen utilizes mature, grafted orchard trees to verify that the resistance of rootstock genotypes to fire blight is maintained under conditions simulating natural infection. Direct inoculation screening and selection have resulted in a high frequency of strong resistance to severe fire blight epidemics in recent orchard inoculation trials.

481 Performance of Macadamia Varieties in Three Agro- ecological Zones

Lusike A. Wasilwa^{*}, Grace W. Watani, N. Ondabu, A. Nyaga, B. Kagiri, and S. Kiiru; National Horticultural Research Centre, Kenya Agricultural Inst., Kenya

Although macadamia was introduced to Kenya in 1946, it was not until the 1960s that commercial cultivation commenced in the central, eastern, and western highlands. In the 1970s, 300 macadamia trees in the Central and Eastern highlands were selected based on nut yield and tree characteristics. In 1981, a subset of 25 of the most outstanding macadamia clones were planted (1979–1987) and evaluated at the National Horticulture Research Centre in Thika. Trial orchards, consisting seven to 15 clones (EMB-1, EMB-2, EMB-H, KMB-1, KMB-3, KMB-4, KRG-1, KRG-3, KRG-4, KRG-15, MRG-1, MRG-20, MRG-24, MRU-25, and TTW-2), were established in 1982, 1986, and 1989. The trials were set up as RCBD with five blocks and three to eight plants of each clone per block. Results from trial orchards show that macadamia hybrids (a natural hybrid between

M. integrifolia and *M. tetraphylla*) EMB-H, KMB-3, and KMB-4 perform well at the higher elevations (>1700 m). The most outstanding clones of *M. integrifolia* with wide adaptability (1400 to 1750 m) were EMB-1, KRG-15, and MRG-20. Three distinct nut-bearing patterns [single peak (most varieties), bimodal peak, and ever-bearing] were observed. Nut clusters contain an average of 10 nuts (*M. integrifolia*) or 25 nuts (macadamia hybrid). Ten-year-old trees yield between 30 to 60 kg of nuts a year with kernel recovery of 28% to 41%.

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In Vivo Micrografts in Almond (*Prunus dulcis*)

Pedro Martinez-Gomez^{*}, Mary Ann Thorpe, and Thomas M Gradziel; Department of Pomology, University of California, Davis, CA 95616

Micrografts have proven a very useful technique when the early propagation of plant material is desired either to invigorate weak material, multiply selected genotypes, or obtained virus-free shoots. This is the situation with the recovery of haploid almond embryos, which occur at low frequency with sexual embryos in twin seeds (i.e., multiple embryos within the same seedcoat). Often these haploid plants show weak growth due to their haploid condition and their poorly developed state within twin seeds. Very little information is presently available, however, concerning the effectiveness of different micrografting techniques for almond. In this work, we examine the success of in vivo micrografting of 'Nonpareil' almond seedlings under different conditions. Variables included type of micro-scion, the rootstock genotype, and the growth stage of the rootstock. Microscions tested included small (3 mm) micro-wedges from either unsprouted or recently sprouted buds. Rootstocks evaluated included the 'Hanson' (peach x almond) hybrid, and Nemared and Nemaguard peach rootstocks. Rootstocks were grafted after either ≈3 weeks of growth, when the tissue was still herbaceous, or after ≈3 months of growth, when the tissue had become woody. Results show significant differences between the treatments. Findings will be discussed both in terms of effectiveness of different approaches and the advantages and disadvantages of their use in breeding programs.

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Identification of S-RNase in Tetraploid Sour Cherry

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Most fruit tree species of *Prunus* exhibit gametophytic self-incompatibility, which is controlled by a single locus with multiple alleles (S-alleles). One interesting aspect of gametophytic self-incompatibility is that it commonly "breaks down" as a result of polyploidy, resulting in self-compatible individuals. This phenomenon is exhibited in the diploid sweet cherry (*P. avium*) and the tetraploid sour cherry (*P. cerasus*), in which most cultivars are self-compatible. Recently, S-gene products in pistil of *Prunus* species were shown to be S-RNases. As sour cherry is one *Prunus* species, it is likely to possess S-alleles encoding pistil S-RNases. To confirm this, we surveyed styler extracts of 11 sour cherry cultivars, including six self-compatible and five self-incompatible cultivars, by 2D-PAGE. As expected, all 11 cultivars tested yielded glycoprotein spots similar to S-RNases of other *Prunus* species in terms of M_r, immunological characteristics, and N-terminal sequences. A cDNA clone encoding one of these glycoproteins was cloned from the cDNA library constructed from styles with stigmas of a self-compatible cultivar, 'Erdi Botermo'. Deduced amino acid sequence from the cDNA clone contained two active sites of T2/S type RNases and five conserved regions of roseaceous S-RNases. In order to determine the inheritance of self-incompatibility and S-allele diversity in sour cherry, we conducted genomic DNA blot analysis for sour cherry germplasm collections and mapping populations in MSU using the cDNA as a probe. To date, it appears as if self-compatibility in sour cherry is not simply controlled by a self-fertile allele as demonstrated in other *Prunus* species.

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Constructing the BAC Contig for the Evergreen Gene Region in Peach [*Prunus persica* (L.) Batsch]

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Evergreen genotypes of peach [*Prunus persica* (L.) Batsch] have been identified in Mexico, where terminal growth on evergreen trees is continuous under

favorable environmental conditions. This evergreen trait in peach is controlled by one single gene (*evg*), and this evergreen condition is homozygous recessive. Four dominant AFLP markers, EAT/MCAC, ETT/MCCA2, EAT/MCTA, and ETT/MACC, were found to be tightly linked to the *evg* locus at 1 cM, 4.6 cM, 5.8 cM, and 11 cM, respectively. All four markers were sequenced and identified. A peach BAC library was constructed by using the pBeloBAC11 vector for building the physical map for the *evg* gene. This library represents four times the coverage of the peach genome with the average insert size of 50 to 70 kb. The EAT/MCAC AFLP marker fragment was used for screening the peach BAC library. A single BAC clone, 18F12, was confirmed to contain this fragment. The final BAC contig for this *evg* gene region and the potential homology between peach and *Arabidopsis thaliana* will be presented and discussed.

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WITHDRAWN

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Expression of β -glucuronidase Gene in Aspen under Control of CaMV35S, Heat Shock and RolC Promoters

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Transgenic hybrid aspens (*Populus tremuloides* x *P. tremula*) were produced by Agrobacterium-mediated transformation and confirmed by polymerase chain reaction. Three promoters (CaMV 35S, Heat shock, and Rol C) were used to drive transcription of chimeric genes -glucuronidase (GUS), npt-II, and rol B. Stem sections in \approx 100 mm thick, leaf blades, and root tips of transgenic aspen were treated with X-Gluc solution for 2 to 12 h in a 37 °C incubator and fixed in a solution containing 5% formaldehyde, 5% acetic acid, and 20% ethanol (FAA) for 10 min. After washing with 50% ethanol twice and clearing with absolute ethanol until free of chlorophyll, the GUS expression (localization and intensity of blue staining) in leaf, stem, and root at different growth stages were evaluated and photographed under the light microscope. When CaMV35S and rol C were used as promoters, the GUS gene was expressed in all parts of mature stem except pith, with the strongest activity in phloem. The heat shock promoter gave rise to very strong expression only in epidermis and phloem. In the young stem, GUS activity was detected in epidermis, parenchyma, vascular cambium, and primary xylem in CaMV35S-GUS transformed aspen shoots. The rol C promoter produced GUS gene expression in all stem tissues. When the heat shock promoter was used, the GUS gene expressed in a more tissue-specific manner, especially in mature stems, with activity mainly in parenchyma. In young leaf tissues, the GUS activity was primarily located in veins and mesophyll. In the mature leaves, no blue staining was found in the main vein. In root tip, the GUS gene driven by CaMV35S and heat shock promoters were expressed in the columella, vascular, and root apical meristem with very strong expression in the root apical meristem. Aspen plants transformed by rol C-Gus construct showed less or no expression in the columella.

51 ORAL SESSION 9 (Abstr. 487–492)
Vegetable Crops: Crop Protection
Monday, 24 July, 2:00–3:30 p.m

487
Strategies to Enhance Production of Annual Globe Artichoke
Anusuya Rangarajan* and Betsy A. Ingali; Dept. of Fruit and Vegetable Science, Cornell University, Ithaca, NY 14853

Annual production of globe artichokes (*Cynara scolymus* L.) requires vernalization of the plants, either through cold treatment of transplants or from natural temperature conditions in the spring. Studies were conducted in upstate New York to determine if artificial vernalization treatments could be achieved by earlier planting dates. Initial trials evaluated two cultivars used for annual production in other parts of the country—'Imperial Star' and 'Green Globe Improved'. Transplants were set in the field with or without a vernalizing cool treatment, to determine the extent of natural vernalization achieved under New York conditions. 'Imperial Star' produced slightly higher marketable yields than 'Green Globe Improved' in 2 years of trials. Vernalization treatment increased the number of plants

producing buds and the marketable yields, when transplants were set after 15 May. Natural vernalization was achieved and cold treatment prior to transplanting did not improve yields of plants established in early May. At later planting dates, vernalizing transplants increased the number of plants producing apical buds (largest) by about 20%, yet, >57% of non-vernalized plants of each variety produced buds within the season. Average bud sizes did not vary with vernalization treatment. A similar number of days from transplanting to first bud harvest (69 to 75) was noted regardless of planting date and size of transplant.

488
The Effect of Population Densities, Vine Training Methods, and Harvest Duration on Shoot Yield of Fluted Pumpkin (*Telfairia occidentalis*)

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Nursery-sown seedlings of *Telfairia occidentalis* were transplanted to the field plots of the National Horticultural Research Inst. in May 1998 and 1999. The treatment involved sowing using three population densities of 75,000; 45,000, and 30,000 plants/ha, which translates to 50 x 50-cm; 100 x 50-cm and 100 x 100-cm spacing. The second experiment involved sowing at 1 x 1-m spacing and one, two, four, zero, eight, and 12 harvests with staking vs. non-staking of vine methods. The studies were of a completely randomized block design using four replications. The results showed that most of the vegetation plant characters measured in the study on one hand were favored by 75,000 plants/ha, while, on the other hand, the highest fruit production occurred in 45,000 plants/ha. Harvesting eight to 12 times gave similar, but significantly higher, vegetative yield than the other lower frequencies. Nevertheless, fruit production in number and weight was superior in plants given the minimum (one or two) pruning. There were no significant differences in the measured plant characters of plants that were staked compared to the non-staked plants. However, fruit yield was better in staked than non-staked plants.

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Using Plant Nutrition Experiments as Models for Exploring Multiple Factor Interactions

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Horticulturists are often interested in evaluating the effect of several treatment factors on plant growth in order to determine optimal growing conditions. Factors could include three or more nutrient elements, or types and rates of irrigation, pesticides or growth regulators, possibly in combination with one another. Two problems with such experiments are how to characterize plant response to treatment combinations and how to design such experiments so that they are manageable. The standard statistical approach is to use linear and quadratic (a.k.a. response surface) regression to characterize treatment effects and to use response surface designs, e.g., central-composite designs. However, these often do a poor job characterizing plant response to treatments. Hence the need for more generally applicable methods. While our goal is to be able to analyze three and higher factor experiments, we started by tweaking two-factor nutrient analysis data. The result was a hybrid model which allows for a given factor to respond linearly or non-linearly. We will show how this was done and our current "in progress" model and analysis for analyzing three quantitative factors.

490
Effects of Rye-Vetch No-till and Habitat Strips and Black Plastic Mulch on Insect Densities, Weed Control, and Fresh-market Cucumber Growth and Yield

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Greater plant diversity is associated with reduced insect pest pressure, but field-scale vegetable production systems incorporating plant diversity have been lacking. Cucumber was grown in 1998 and 1999 at the Virginia Tech Kentland experimental farm, by direct seeding or transplanting into rye/vetch mixture rolled to make a no-till mulch alternating with strips of vetch left to flower as a habitat for beneficial insects between cucumber rows, or direct-seeded into black plastic mulch between habitat strips or with bare soil between rows. Rye and hairy vetch were seeded at 56 kg·ha⁻¹ each the preceding fall; only rye was planted in plots without habitats. A rippled coultter, cutting shank, and daisy wheels mounted on a

tractor-drawn toolbar enabled a belt-driven seeder to seed cucumbers without pulling the no-till mulch. One hand weeding in cucumber rows at 3 weeks after planting (WAP) provided weed control equivalent to pre-emergence herbicide. At 3 WAP, no-till transplanted cucumbers had higher above-ground plant dry weights than no-till direct seeded cucumbers in both years, but, at 6 WAP, cucumber above-ground plant dry weights were equal (1999) or higher (1998) in direct seeded no-till than in transplanted no-till or black plastic mulch on bare soil. In 1999, Pennsylvania leatherwings, *Chaulioognathus pennsylvanicus* DeG. (Coleoptera: Cantharidae), a cucumber beetle predator, had higher densities and cucumber beetles lower densities in no-till plots than in black plastic mulch plots, and bacterial wilt incidence was reduced in plots with habitat strips and no insecticide application compared to plots without habitat strips and four insecticide applications. Cumulative marketable yields in no-till were 59% higher in 1998 and 23% higher in 1999 compared to yields on black plastic mulch.

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Intercropping of Spring-planted Sugarcane with Sweetpotato and Cowpea Under Conditions of Middle Egypt

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Sugarcane, cowpea, and sweetpotato were grown in sole and intercrop systems at Experimental Station, Mallawi, Egypt (lat. 28°N) in the two spring seasons in 1996 and 1997 to determine the effects of cropping system on yield and yield components. The soil texture of the experimental site was loamy with a pH of 8.2. Results showed significant differences in yield and yield components of cane, cowpea, and sweetpotato due to intercropping treatments. Sugarcane intercropping caused significant reduction in yield of sweetpotato and cowpea. The average yields of both sweetpotato and cowpea in the intercrop system were about 19.8 % and 29.9 %, respectively, of those of sole crop yields. Moreover, sweetpotato was more competitive than cowpea when intercropped. Furthermore, the magnitude of differences in sugarcane was low between sole and intercropped system as compared to sweet potato or cowpea. All yield attributes of cowpea and sweetpotato were better for the sole planted as compared to those for intercrop treatments. Intercropping of one cowpea row sown at 15-cm hill spacing, between two sugarcane rows produced the maximum Land Equivalent Ratio (LER). This work suggests that the best cash return could be obtained when a single cowpea row planted at 30-cm hill spacing, is intercropped between two spring-planted sugarcane rows.

492

Health Aspect of Using Recycled Treated Wastewater in Crop Production

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Treated wastewater will play important role in the implementation of Kuwait National Agriculture Development Plan. As a substitute for brackish or fresh water in irrigation, treated municipal wastewater can be a practical solution. Nevertheless, special health and environmental considerations should be carefully assessed when using this water source. These considerations include potential infection with human pathogens, effects of heavy metals on the public health, and the ecological consequence on soil and water resources at large. These topics were investigated under controlled environment using a range of crops and two types of irrigation water: a tertiary treated wastewater source and fresh tap water as a control. Soil, water, and plant samples were collected at fixed intervals and were analyzed for total viable count; total Coliforms; faecal Coliforms; and faecal Streptococci, Salmonellae, Shigella, Ascaris imbricoides and pathogenic viruses. In addition, we measured for nine heavy metals (Cd, Zn, Fe, Mn, Cu, Ni, Co, Cr, and Pb). Soil salinity and build-up of sodicity in soil and ground water sources also were investigated for any changes that could indicate a potential long-term degradation effect. The results after 3 years of study indicate that the generated tertiary treated wastewater is of high quality. Its potential pathogenic content is below the guidelines recommended by WHO for using wastewater in mixed agriculture, and therefore, it had no accumulative effect on the irrigated soil or the different parts of plant tissues that were analyzed. However, treated effluent have occasionally exhibited pathogenic index higher than permitted levels reflecting the fluctuating nature of wastewater treatment. Heavy metals content of irrigation water and from the irrigated soils were negligible, and the plant tissues that were analyzed contained metallic contents below the established range in IPE. The

treated water had low TDS but high sodium content with 25–35 SAR values; however, the effect on the irrigated soil was insignificant due to the calcareous nature of the soil used. This study used drip irrigation system and under similar conditions no health problems will be expected when using tertiary treated wastewater for irrigation. To minimize potential risk to the consumers, specific guidelines are recommended on the type of crops to grow and the horticulture practices to be used.

52 ORAL SESSION 10 (Abstr. 493–500) Floriculture/Foliage: Production/Physiology/Postharvest Monday, 24 July, 2:00–4:00 p.m

493

The University Horticultural Department as an Introducer of New Ornamental Crops, Without a Plant Breeder—Is It Possible?

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The New Crop Program at the Univ. of Georgia has introduced about a dozen crops new to the floriculture and ornamental plant industry. None of the selections arose from controlled crosses or traditional plant breeding, but were due to discovery, natural plant mutation, and plant donations from interested individuals. All successful introductions benefitted from feedback from the industry, evaluation, research, and promotion of the taxa. No marketing was done by the university. Less than 10% of plants trialed were introduced to the industry, and not all introductions were equally satisfactory. The keys to new crop introduction are feedback from the industry, an industry willing to experiment with new material and to be as highly selective as possible in choosing the crops to be introduced. The disadvantages and benefits of establishing a New Crop Program will be discussed.

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Evaluation of Interior Performance of Six Cultivars of *Aglaonema* and *Dieffenbachia*

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Tissue culture plugs of *Aglaonema* 'Cory', 'Maria', and 'Silver Queen' and *Dieffenbachia* 'Panther', 'Snowflake', and 'Sport Lynn' were potted singly in 15-cm pots and grown in a shaded greenhouse under a photosynthetic irradiance (PI) of 100 mmol·m⁻²·s⁻¹. Eight months after potting, 27 plants of each cultivar were placed in nine interior evaluation rooms under three different PI levels (three rooms per level): 4, 8, and 16 mmol·m⁻²·s⁻¹. In addition, three plants of each cultivar were maintained in the original greenhouse for the duration of the experiment. Number of leaves, plant height and width were monitored monthly. Recently matured leaves were removed at 3-month intervals for 9 months for determination of fresh and dry weight, leaf area, and percentage leaf variegation. Variegated leaf area was assessed using digitized leaf images. Interior PI levels affected growth parameters, but the degree of response was cultivar-dependent. Smallest leaves developed on plants grown under 4 mmol·m⁻²·s⁻¹ and largest leaves developed under 16 mmol·m⁻²·s⁻¹. Leaf area of *Dieffenbachia* 'Sport Lynn' showed the greatest response and *Aglaonema* 'Maria' the least response to PI levels. Percentage leaf variegation of *Dieffenbachia* 'Snowflake' was least affected and *Dieffenbachia* 'Sport Lynn' was most affected by PI levels. Fresh leaf weight of unit area decreased as PI levels decreased from 16 to 4 mmol·m⁻²·s⁻¹, however, the decrease in unit area was most pronounced in cultivars that maintained the highest quality ratings. Based on the results of this study, *Aglaonema* 'Maria' and *Dieffenbachia* 'Snowflake' had the most satisfactory interior performance within their respective genera.

Public Preferences for Poinsettia Cultivars

J.E. Barrett*, J.C. Bradley, C.A. Bartuska, T.A. Nell, and D.C. Clark; Environmental Horticulture Dept., University of Florida, Gainesville, FL 32611

More than 60 new poinsettia cultivars have been introduced in the past 3 years, and many of these have nontraditional bract color or plant form. About 75% of all poinsettias sold are red and 'Freedom' represents more than 50% of the red poinsettia market in the United States. In Fall 1999, 212 individuals were surveyed and asked to indicate their favorite 10 cultivars out of the 89 in a cultivar trial. The top choices were 'Plum Pudding', 'Winter Rose Dark Red', 'Cranberry Punch', and 'Monet Twilight', which were selected by 48%; 38%; 32%, and 31% of the participants, respectively. These cultivars are all nontraditional in appearance. The top red cultivars were 'Freedom', 'Orion', and 'Red Velvet', which were selected by 27%, 26%, and 23%, respectively. The participants were then asked to rate on a 1 to 10 (most favorable) scale 15 plants that represented different poinsettia forms and colors. Five of these plants were cultivars with different shades of red that the industry easily separates. However, the participants' ratings of these were not significantly different, which indicates the shade of red in bract color may be more important to the industry than it is to the public. These results also indicate that there are strong differences in individual preferences for poinsettias. Each of the 15 plants received both high and low ratings. Also, of the participants that included 'Freedom Red' in their top 10 selection, only 13% of those selected 'Plum Pudding', which has purple bracts, and only 11% selected 'Winter Rose Dark Red', which has a nontraditional plant form.

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Consumer Preference of Edible Flower Color, Container Size, and Price

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Two surveys were conducted to determine the importance of characteristics of containers of edible flower which could be sold to consumers in retail outlets. Self-selected participants at Bloomfest at Cobo Hall in Detroit, Mich., were assigned to one group that rated the importance of attributes such as edible flower color of *Viola x wittrockiana* 'Accord Banner Clear Mixture', color combinations, container size, and price of the container. Participants assigned to a second group rated color, color combinations, and size. Flower color was allocated the most points in the purchasing decision (63% for the first group and 95% for the second group), with a mixture of all three colors (blue, yellow, and orange), proving to be the most desirable. Responses were subjected to Conjoint Analysis (SPSS Inc., Chicago), which resulted in the formation of three groups of customer segmentation. The groups were labeled "Likely Buyer" who had eaten and purchased edible flowers before and rated characteristics of edible flowers favorably; "Unlikely Consumer" who had eaten edible flowers before and had rated characteristics of edible flowers unfavorably; and "Persuadable Garnishers" who had not eaten edible flowers before, but were very likely to purchase edible flowers for a garnish for a meal.

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Increasing Postproduction Quality and Longevity of Flowering Potted Plants

Terril A. Nell*, Ria T. Leonard, Jim E. Barrett, and David G. Clark; Department of Environmental Horticulture, University of Florida, Gainesville, FL 32611

Production and postproduction factors were examined to evaluate effects on postproduction performance and longevity of several varieties of potted African violets, carnations, chrysanthemum, cyclamen, gerbera, Hiemalis begonia, hibiscus, hydrangea, kalanchoe, and lisianthus. Various N rates (150–600 ppm) and fertilizer termination 2 to 3 weeks prior to flowering were evaluated. Chrysanthemums, hydrangea, and lisianthus had better quality and longevity at N rates ranging from 200 to 300 ppm, while all other crops performed best at 150 ppm N. Terminating fertilizer had no effect on longevity or quality of carnation, gerbera, Hiemalis begonia, hydrangea, or kalanchoe, while chrysanthemum and cyclamen had a significant increase in longevity when terminated. Lisianthus had an increase in quality and longevity when fertilizer was continued to the end of production. Shipping at the proper bud developmental stage significantly influenced flower opening and longevity in the postharvest environment. Lisianthus and hydrangea need to have at least 75% of the buds fully opened, while carnations, chrysanthemum, cyclamen, and kalanchoe need at least 25% to 50% open. Hiemalis begonia, a very long-lasting potted plant, tolerated a range of 10% to

75% open flowers at shipping. Optimum transport temperature and transport duration varied for each crop. Generally, transporting for 3 days at 2 to 7 °C was best for carnation, chrysanthemum, and gerbera, while transporting at 7 to 12 °C was best for cyclamen, Hiemalis begonia, hydrangea, kalanchoe, and lisianthus. Hibiscus performed best when transported at 18 °C. Longevity and quality were maximized when maintained at 18 to 21 °C at 14 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$. Differences in variety production was a major factor in postproduction performance.

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Postharvest Care and Handling Practices for Cut Poinsettia cv. 'Winter Rose Dark Red'

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The traditional use of poinsettias has been as potted plants. A new poinsettia variety, 'Winter Rose Dark Red', is performing well as a cut flower, lasting 2 to 3 weeks. Various postharvest handling procedures were examined, including stem processing methods at harvest, storage and transit conditions, as well as handling practices at the wholesale, retail, and consumer levels, to determine the best handling practices to maximize quality and longevity. At harvest, traditional latex controlling techniques, such as dipping stems in 95% ethanol for 10 min and burning or boiling stem tips were tested. Stems wilted faster when dipped in ethanol or burned. The woody nature of the stem contains little latex compared to traditional varieties; thus, no latex-controlling methods are needed or beneficial. After harvest, there was no benefit found in hydrating stems in a commercial hydration solution compared to plain water. Transport and/or storage conditions between 10 to 15 °C for 3 to 4 days maximized longevity. Chilling injury occurred when transported at 4 °C. Leaves and bracts wilted when stored dry in a box, but recovered within 12 to 24 h when stored for 2 days. Leaves abscised after exposure to short-term wilting but no bract abscission occurred. Storing stems in a 10% bleach solution prevented wilting and reduced bacterial growth. Bracts were sensitive to mechanical injury during transit, resulting in bruising lesions on the bracts, which increased sensitivity to bract edge burn. Stems declined faster when maintained in a floral preservative compared to water during the consumer phase.

500

Evaluating the Benefit of Cutting Flower Stems Underwater

Ayumi Suzuki*, Ria T. Leonard, Terril A. Nell, Jim E. Barrett, and David G. Clark; Department of Environmental Horticulture, University of Florida, Gainesville, FL 32611

It has traditionally been recommended to cut flower stems underwater to reduce blockage and improve water uptake, although little scientific information relates this practice to vase life. The purpose of our study was to evaluate the benefit of this processing technique on quality and longevity of several cut flowers species. Stems were either cut dry or cut wet under deionized water with a stainless steel blade and placed into vases containing a commercial floral preservative. Water samples were obtained from the cutting tank over time during stem processing for bacteria counts. Stems were maintained at 2 °C at 10 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ (12 h/day). The results were variable from shipment to shipment, possibly due to differences in stem quality or cutting water quality. In most cases, cutting underwater had no effect on longevity of alstroemeria, chrysanthemums, gerbera daisy, roses, or snapdragons. However, in a few instances, cutting underwater improved longevity slightly. Cutting stems underwater was consistently effective in increasing longevity 2-4 days for carnations. Bacteria counts in the cutting tank water after 500 stems were processed were $6/34 \times 10^6$ propagules/mL and increased to 1.00×10^7 propagules/mL after 1000 stems. The increase in bacteria decreased leaf quality in roses and reduced the number of snapdragon flowers that opened, but did not affect longevity. In gerberas, however, longevity decreased 2 days. A high concentration of bacteria in the cutting water may effect quality and longevity of many cut flower species and may negate any benefit in cutting stems underwater.