

was 1 °C, which prevented discoloration and decay over the 8-day storage period. Nonmelting flesh peach cultivars are better suited for fresh-cut processing than melting flesh cultivars because their firmer texture allows the use of riper fruit with better flavor than the less ripe fruit that must be used for fresh-cut melting flesh peaches.

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Substrate on Apple Fruit Increased Sooty Blotch Incidence

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The potential mechanism of susceptibility of apple (*Malus domestica* Borkh.) fruit to sooty blotch due to carbohydrate leachates was examined. Fruit received applications of 0.5% apple juice to the fruit cuticle in order to mimic leachates. Nine cultivars of apple were selected from a variety block of potentially disease resistant breeding stock. Intact fruit on selected limbs received 0.5% apple juice applications on eight evenly spaced occasions during development. Trees received a minimal fungicide program only. Leachate samples from the fruit cuticles were collected monthly by immersion of whole, detached fruit in dH₂O for 60 min. At harvest, fruit were evaluated for skin roughness, fruit rots, sooty blotch, sooty mold, flyspeck, and insect injury. Despite drought conditions, sooty blotch and sooty mold showed strong increases in disease intensity ratings, while flyspeck and skin texture damage showed moderate increases in intensity due to the dilute juice applications. Fruit rots and insect damage were unaffected by the juice applications.

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Changes of Fruit Structure and Sugar Contents during the Fruit Development Processes in 'Yumyeong' Peach [*Prunus persica* (L.) Batsch]

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'Yumyeong' is one of the most popular peach varieties in Korea. This study was conducted to monitor the developments of cells and tissues, and the changes in sugar contents during the whole fruit growth stages. At bloom, there were two rows of vascular tissues, and the number and the position of internal vascular bundles were consistent during the fruit growth; however, the number of vascular tissues increased and the distribution was irregular in the flesh tissues. The tissues between the inner integument and the internal vascular bundles showed different development characteristics from other parenchyma cells, which consisted of small and dense cells containing tannins. Therefore, it was found that the nucleus of peach consisted of inner epidermis and cells in the internal vascular tissues. The outer epidermis consisted of single layer cells at bloom and was changed into one to two layers by horizontal cell division 14 days after full bloom. At 30 days after full bloom, the epidermis consisted of five to six layers by vertical cell division. The cell layers of the outer epidermis gradually decreased to one to two layers at maturity. The observations on the changes in the epidermis confirmed that some of the cells of the hypodermis of peach fruit originated from the cells of outer epidermis. Tylosis was observed from 35 days after full bloom, and the size and number of tylosis increased until full fruit maturity. The sucrose content sharply increased from 50 days to 120 days after full bloom, then decreased slightly. After stone hardening ended, other solids showed a gradual decrease from 80 days after full bloom.

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Response of Valencia Orange Trees to the Foliar Application of Different Potassium Salts: Their Effects on the Vegetative Growth, Leaf Miner Infestation, and Leaf Mineral Contents

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Valencia orange trees [*Citrus sinensis* (L.) Osb.], budded on sour orange (*C. aurantium*) rootstock, were sprayed with four different potassium salts during 1995 and 1996. Twenty 5-year-old trees were sprayed once per month with one of the following material. K0: distilled water, K1: potassium green (a compound of different potassium salts, 35% K₂O), K2: potassium nitrate (35% K₂O), K3: potassium citrate (35% K₂O), or K4: potassium sulfate (51% K₂O). The vegetative growth occurred in three distinct successive cycles, i.e., spring, summer, and autumn. These cycles differed in time of commencement, duration and termination with respect to season. All potassium treatments significantly increased

the shoot length and number of leaves/shoot for the three growth cycles. However, potassium green was superior overall other treatments. Percentage of leaf miner infestation was reduced at all potassium treatments. Potassium applications significantly increased leaf contents of N, P, K and decreased Ca and Mg levels.

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Impact of Rootstock on Maturity and Storage of Valencia Orange Fruits

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This investigation was carried out on 13-year-old Valencia orange trees [*Citrus sinensis* (L.) Osbeck] budded on five different rootstocks. Heat unit accumulation (temperature above 12.5 °C) for fruits worked on the various rootstocks were calculated from full bloom to maturity stage. Valencia fruits on Troyer citrange (*C. sinensis* x *Poncirus trifoliata*) and Carrizo citrange (*C. sinensis* x *Poncirus trifoliata*) rootstocks matured earlier when compared to those growing on Cleopatra mandarin (*C. reticulata* Blanco), Volkamer lemon (*C. volkameriana* Ten. and Pasq.), and sour orange (*C. aurantium*) rootstocks. The results showed that the Valencia fruits, regardless of rootstock, could be stored for different periods under different conditions. However, in order to avoid degradation in fruit quality, storing periods should not exceed 21, 60, and 120 days under room conditions (25 °C and RH 25% to 35%), 4 °C (RH 80% to 85%), and 8 °C (RH 80% to 85%); respectively.

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Apogee™ Controls Shoot Growth and Fruit Parameters

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The efficacy of Prohexadione-Ca on vegetative and reproductive parameters was tested for 3 years on three apple cultivars (Golden Delicious, Braeburn, and Fuji) at concentrations ranging from 125 up to 350 ppm. The Prohexadione-ca was applied after shoots reached 5 cm length, for 1 month. In all cases, Prohexadione-Ca reduced shoot growth, showed the tendency to increase fruit size and to enhance return bloom. In addition, it increased leaf coloration and higher chlorophyll content, and it induced higher photosynthetic efficiency than the control. The relationships among shoot reduction, chlorophyll content and photosynthetic efficiency are discussed.

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Studies on Fruit Thinning and Growth in Apple Cultivars

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Experiments were carried out for 3 years on 'Gala' and 'Fuji' apple cultivars. The efficacy of the compounds applied during blooming (ATS, Armothin) and at 10 mm king fruit diameter (BA, CPPU, and NAA) was studied. Results showed a poor efficacy of the chemicals applied during bloom, while compounds applied at fruit set showed interesting results. Among the new chemicals, cytokinins were the most effective, although their effects were related to the cultivar: BA performs better than CPPU on 'Fuji' while vice versa on 'Gala'. In addition, both chemicals induced a slightly higher °Brix content, and acidity level showed the tendency to increase L/D ratio of the fruits as compared to controls. Fruit thinning and the strategies to enhance fruit size are applied early in the season and the problem remains, to assess their effectiveness as early as possible in order to adapt the management techniques (e.g., further thinning, if applicable, or fine-tuning of nutrition and irrigation, etc.) to enable the fruit to reach their maximum potential development. A modelling approach proposed by Lakso et al. (1995) postulates that apples grow in weight according to an equation termed "exponential" (Goudriaan and Monteith, 1990) because after an initial phase of exponential growth (cell division), the apple enters a phase of linear growth (cell expansion) lasting up to harvest. The effectiveness of a thinning agent can therefore be evaluated and explained in terms either of the number of cells of the cortex tissue, or of their volume, or both. In addition, assessing the slope of the linear phase as early as possible might provide a prediction tool to evaluate size at harvest. This paper presents data from apple thinning trials on several cultivars. The effectiveness of these applications has been evaluated via an analysis of the cell parameters (number, volume and intercellular spaces) of the fruit's parenchyma cortex tissue. Also, fruit growth data have been used to test the possibility to predict fruit size at harvest once the fruit reaches the phase of linear growth.

Chemical Changes in the Cell Wall Composition of Calcium-infiltrated 'Golden Delicious' Apples

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'Golden Delicious' apples (*Malus x domestica* Borkh.) were pressure-infiltrated after harvest with 0%, 1%, 2%, 3%, or 4% CaCl₂ solutions (w/v) and the chemical composition of the cell wall of the cortical tissue 2 to 4 mm under the epidermis was studied. The mineral composition of the control cell wall (0% CaCl₂) was not affected by the pressure infiltration process. In addition, no significant change was noticed in cell wall associated protein, uronic acid, total polysaccharides, or non-cellulosic neutral sugar contents except for xylose and rhamnose, which decreased (-25%) and increased (+20%), respectively. When apples were infiltrated with CaCl₂, Ca content of the cell wall increased and maximum accumulation was achieved with a 2% CaCl₂ solution. Calcium infiltration also induced a two-fold increase in Na, a 27% decrease in P, and a 40% decrease in protein content. These data suggest that chemical changes occurring after Ca infiltration are not related to pressure infiltration alone, but are mainly due to the Ca accumulation in the cell wall after pressure infiltration of CaCl₂ solutions. Saturation of the available binding sites for Ca occurred in the cell wall when fruit were infiltrated with 2% CaCl₂, as no further significant changes in the cell wall chemical composition was detected in fruits infiltrated with 3% or 4% CaCl₂.

Stripped Corn Oil Emulsion Alters Ripening, and Reduces Scald and Coreflush in 'Granny Smith' Apples, and Scald and Decay in 'd'Anjou' Pears

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'Granny Smith' apples (*Malus x domestica* Borkh) and 'd'Anjou' pears (*Pyrus communis* L.) were dipped in a 2.5%, 5%, or 10% stripped corn oil (α -tocopherol <3 mg·kg⁻¹) emulsions, 2000 mg·L⁻¹ diphenylamine (DPA), respectively, at harvest and stored in air at 0 °C for 8 months. Untreated fruit served as controls. In oil-treated apples and pears, ethylene and α -farnesene production rates were lower in early storage and higher in late storage than in control. Control fruit developed 34% scald in 'Granny Smith' apples and 23% scald in 'd'Anjou' pears after 6 months storage, whereas fruit treated with oil at 5% or 10%, or with DPA at 2000 mg·L⁻¹ were free from scald. After 8 months storage, oil at 10% was as effective as DPA in controlling scald in pears, whereas in apples, fruit treated with 10% oil developed 18% scald and DPA-treated fruit were scald-free. DPA-treated apples developed 32% senescent scald, while 5% or 10% oil-treated fruit had none. Oil-treated fruit were greener, firmer, and contained more titratable acidity after 8 months of storage than control or DPA-treated apples and pears. In 'Granny Smith', 100% of the controls and 79% of the DPA-treated fruit developed coreflush after 8 months of storage, but both 5% and 10% oil-treated fruit were free from coreflush. In 'd'Anjou', 34% of the controls and 27% of the DPA-treated fruit showed decay after 8 months of storage, compared with 5% decay in 5% oil-treated fruit, and no decay in 10% oil-treated fruit.

Lovastatin Inhibits α -Farnesene Biosynthesis and Scald Development in 'Delicious' and 'Granny Smith' Apples and 'd'Anjou' Pears

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Effects of Lovastatin treatment on ethylene production, α -farnesene biosynthesis, and scald development were studied using 'Delicious' and 'Granny Smith' apples and 'd'Anjou' pears stored in air at 0 °C. During 6 months of storage, Lovastatin did not affect internal ethylene concentration, but reduced α -farnesene production in a concentration-dependent manner in both apples and pears. Lovastatin reduced scald at 0.63 mmol·L⁻¹ and inhibited scald completely at 1.25 or 2.50 mmol·L⁻¹ in 'Delicious' and 'Granny Smith' apples. In 'd'Anjou' pears, Lovastatin at concentrations from 0.25 to 1.25 mmol·L⁻¹ inhibited scald completely. After 8 months of storage, the inhibition of scald in both apples and pears by Lovastatin was concentration-dependent, but none of the concentrations eliminated scald. Compared with 11.8 mmol·L⁻¹ diphenylamine (DPA), Lovastatin treatment reduced scald to the same level at 1.25 mmol·L⁻¹ in 'd'Anjou' pear and 2.50 mmol·L⁻¹ in 'Delicious' and 'Granny Smith' apples. Compared to the con-

trols, Lovastatin did not affect fruit color, firmness, soluble solid contents, or titratable acidity during storage in either apple or pear.

Effects of Prohexadione-Ca on Gibberellin Levels in Young Apple Shoots

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Prohexadione-Ca (BAS 125 W) is a new growth retardant for the inhibition of excessive vegetative growth in apple and other plant species. From work with enzyme preparations, it is known that prohexadione-Ca mimics 2-oxoglutaric acid, the co-substrate of dioxygenases, which catalyze late steps in gibberellin (GA) biosynthesis. As a result, the formation of growth-active GAs is reduced. In order to have a better understanding of its effects in intact plants, we have analyzed the GA status of treated and untreated apple plantlets. In a typical experiment, the following results were obtained: Plants (cv. Jonagold on M9 at 19 cm of new shoot growth) were sprayed until run-off with an aqueous preparation containing 25 ppm of active ingredient. After 22 days of cultivation under greenhouse conditions, total new shoot growth of the controls and the treated plants was 55 cm and 44 cm, respectively. In the apical part of this material the following GAs (roughly ordered in biosynthetic sequence) were detected at the following levels (control/treated in microgram per kilogram dry weight): GA₁₉ (31/62), GA₂₉ (24/36), GA₂₀ (11/20), GA₁ (4/3), and GA₈ (8/3). These results clearly demonstrate that prohexadione-Ca blocks primarily the hydroxylation of GA₂₀ into GA₁. This leads to reduced levels of the highly active GA₁ and of GA₈, its inactive metabolite, whereas GA₂₀ and the other inactive precursors accumulate. The data support older observations obtained in vitro, which indicate that GA₂₀ 3 β -hydroxylase and related dioxygenases are the primary targets of prohexadione-Ca and similar compounds.

Berry Quality and Photosynthate Partitioning in Response to Plant Growth Regulators in Grape

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The effects of 2,3,5-triiodobenzoic acid (TIBA) and naphthaleneacetic acid (NAA) on berry maturation and photoassimilates partitioning were investigated. Five-year-old potted 'Kyoho' grape grown under a non-heating glasshouse were used. TIBA (200 mg/L) and NAA (200 mg/L) were applied to clusters at the beginning of veraison (45 days after full bloom). TIBA application increased not only soluble solids concentration in the juice but also anthocyanin content of peel, compared with those of control. On the other hand, the application of NAA reduced berry growth and delayed the berry maturation with harder flesh, lower soluble solids, higher acidity and poor coloration. In order to examine the effect of both plant growth regulators on photoassimilates partitioning in plant tissues, the whole plants were fed with ¹³C₂ at 10 days and 20 days after application of TIBA and NAA. The ¹³C distribution of pericarp and peel in NAA application was found on the lowest among the treatments. However, there were no significant differences in the ¹³C distribution and ¹³C absorption rate of pericarps between TIBA and control. These results indicate that NAA weakened the sink activity in grape berries, resulted in smaller berry size and the delay of maturation, whereas the berry ripening induced by TIBA application could not be explained by the distribution of photoassimilates in grape berries.

Foliar Application of Urea to Citrus: Effects of Non-ionic and Organosilicone Adjuvants

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Urea solutions, with or without non-ionic (X-77) and organosilicone (L-77) surfactant, were applied to *Citrus* leaves and isolated cuticles to examine adjuvant effects on urea uptake and leaf net gas exchange. When compared to X-77, L-77 exhibited superior features as a surfactant, resulting in smaller contact angles of droplets deposited on teflon slide. Both L-77 and X-77 had a strong effect on penetration rate of urea within first 20 min of experiment. Effect of L-77 on urea

penetration rate decreased quickly within next 20 min, whereas the effect of X-77 was sustained over a 24-h period following application. When compared to solution of urea alone, addition of X-77 to urea resulted in significant increase of the total amount of urea that penetrated the cuticles. The effect of L-77 was smaller, although the total amount of urea that penetrated the cuticles within a 4-day period was similar for both surfactants. Solutions of either urea alone, urea+L-77 and urea+X-77, or L-77 alone, induced a negative effect on net CO₂ assimilation (ACO₂) for 4 to 24 h after they were sprayed onto leaves. X-77, when applied alone, had no effect on ACO₂. Scanning electron microscopy revealed that 1 h after application, leaf surfaces treated with X-77 appeared to be heavily coated, as opposed to those treated with L-77, which appeared similar to untreated control leaves.

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Effect of Streptomycin Walnut Blight Sprays on Nut Drop

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Walnut Blight caused by the bacteria *Xanthomonas campestris* pathovar *juglandis* is a very destructive disease for California walnut production. Streptomycin is an effective disease control material; however, Streptomycin sprays can result in significant nut drop 3 to 5 weeks after spray application. We investigated the basis for walnut drop following applications of Streptomycin (Agrimycin) for walnut blight control. Flowers and developing nuts were collected from four treatments, plus an unsprayed control. 200 ppm Streptomycin was applied at 1) budbreak; 2) pre, full, and post-bloom; 3) postbloom; 4) budbreak and postbloom; 5) untreated control. Samples were collected regularly beginning at the first budbreak spray and extending through the period of nut drop. Samples were fixed and prepared for histological examination. In treatments with a high incidence of nut drop, the embryo failed to develop. Examination of the stigma and style in flowers from these treatments showed inhibited pollen tube growth. Results indicate that Streptomycin inhibits pollen tube growth, which precludes fertilization. This pattern of development and timing of nut drop following Streptomycin application at full bloom is similar in all ways to unpollinated walnut flowers. Nut growth and development appear normal for 3 to 5 weeks; then nuts abort. If Streptomycin became available for walnut blight control, sprays timed to coincide with pistillate bloom and pistillate flower receptivity should be avoided.

149 POSTER SESSION 18 (Abstr. 189–217)

Crop Physiology

Wednesday, 26 July, 1:00–2:00 p.m.

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The Use of Hydrophobic Clay Films as a Barrier to Ice Nucleation in Plants

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Most plants exhibit the ability to supercool to some extent without freezing. The extent of supercooling, however, is limited by the action of intrinsic and extrinsic ice nucleating agents which initiate ice formation and propagation within a plant at relatively warm subzero temperatures (–1.5 to –3.5 °C). In herbaceous plants, extrinsic ice-nucleating agents (such as ice-nucleation bacteria, dew, and other good nucleating agents) significantly limit the ability to supercool below 0 °C. It is believed that with an absence of these extrinsic nucleating agents that plants could supercool to less than –4 °C. Other evidence indicates that intrinsic nucleating agents may also significantly limit the extent of supercooling. Questions also exist about nucleation in woody plants and especially the new growth (flowers, leaves, and shoots) present in spring. A better understanding of how freezing is initiated in plants has been limited by the inability to determine and visualize the initial site of ice nucleation and pattern of ice propagation. We have used infrared video thermography to study freezing in young tomato (*Lycopersicon esculentum*) plants and to determine if a hydrophobic barrier on the plant surface could prevent the action of extrinsic nucleating agents such as Ice + bacterial strain (Cit7) of *Pseudomonas syringae* from initiating freezing within a plant.

Tomato plants were grown in a greenhouse in individual pots and used when they were 4 to 6 weeks old. Freezing tests were conducted in a programmable freezing chamber, and freezing was visualized and recorded on videotape using an infrared radiometer. Freezing of the plants was extrinsically induced by the application of droplets (5 µl) of water containing Cit7. To provide a barrier to the action of extrinsic ice-nucleating agents, an emulsion of hydrophobic kaolin was applied to the plant surface before applying an extrinsic nucleating agent. Results indicate that dry, young tomato plants can supercool to as low as –6 °C whereas plants having a single droplet of Cit7 would freeze at –1.5 to –2.5 °C. Applying the hydrophobic barrier blocked the effect of Cit7 and allowed the plants to also supercool to –6 °C, despite the presence of frozen droplets. Experiments under natural freezing conditions are in progress.

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Growth Response of Four Tree Species to Fertilization and Humate Additives to CU Soil

Jason Grabosky¹ and Nina Bassuk²; Dept. of Environmental Horticulture, Univ. of Florida, Gainesville, FL 32611-0670; ²Cornell Univ., Dept. of Floriculture Ornamental Horticulture, Program Leader: Urban Horticulture Institute, Ithaca, NY 14853

CU soil is a material primarily composed of clay loam soil and crushed stone designed for use under pavement to promote street tree root growth in a durable pavement section, such as sidewalks or parking lots. One concern is the low total soil fraction from which tree roots can meet nutritive demands. At issue is the long-term nutrient management of street trees once the root zone has been rendered inaccessible due to the pavement wearing surface, although in 3-year field tests, there were no differences found between a CU soil material and an agricultural field control. CU soil treatments were produced in a factorial design with a patent applied for processed humate additive, and a nursery production fertilization treatment. Bare-root seedlings of *Salix nigra* Marsh, *Platanus x acerifolia* Willd., *Ginkgo biloba* L., and cell plugs of *Ficus benjamina* L. were grown in treatment containers for 5 months. A Minolta SPAD-502 was used to evaluate relative chlorophyll content as an indication of leaf tissue nutrient levels. Plant growth as a function of new growth dry weight was calculated. Soil samples were collected at the end of the study and were analyzed to evaluate the impact of humate admixes in nutrient availability. The fertilization treatments positively influenced leaf color and growth for all species. The CU soil control plants displayed significantly lower chlorophyll levels, but overall growth differences were less dramatic—insignificant in some cases. The humate additive did not consistently affect leaf color. The humate additive alone did not affect plant growth, but a significant positive interaction with the fertilizer treatment was evident for *Platanus* and *Ficus*. The positive interaction was insignificant in *Salix* and non-existent in *Ginkgo*.

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Use of the Minolta SPAD-502 to Determine Chlorophyll Concentration in *Ficus benjamina* L. and *Populus deltoides* Marsh Leaf Tissue

Felix Loh¹, Jason Grabosky², and Nina Bassuk³; ¹Dept. of Floriculture, Ornamental Horticulture, Cornell Univ., Urban Horticulture Institute, Ithaca, NY 14853; ²Dept. of Environmental Horticulture, Univ. of Florida, Gainesville, FL 32611-0670; ³Dept. of Floriculture, Ornamental Horticulture, Cornell Univ., Urban Horticulture Institute, Ithaca, NY 14853

The Minolta SPAD meter has been used to evaluate chlorophyll concentration in plant material to provide an inexpensive method to collect rapid, nondestructive data. Correlations of SPAD data and chlorophyll concentrations in corn have been very accurate ($r^2 = 0.95$), and can be used to monitor plant nutrient status as a function of chlorophyll concentration. There has been evidence that the calibrated accuracy of the SPAD meter is diminished at low and high concentrations of chlorophyll. Our study attempted to build the same type of background information for two tree species for use in evaluating plant response in experimental media experiments. *Ficus benjamina* L. and *Populus deltoides* Marsh were grown in containers of varied media. Leaf tissue was measured with a Minolta SPAD-502, and the tissue was then removed and processed with *N,N*-dimethylformamide for analysis in a spectrophotometer. The remainder of the leaf sample was analyzed in an ICAP for tissue nutrient levels. Data were analyzed to evaluate the usefulness of the SPAD meter for woody plant leaf tissue evaluation and to develop calibration curves for use in future studies. There was a positive correlation ($r^2 = 0.943$ in *Ficus*) between SPAD data and combined concen-

trations of chlorophyll a and b. Accuracy of the SPAD data was diminished when chlorophyll concentrations were low (SPAD <20, chlorophyll <450 µg·mL⁻¹) and high (SPAD >45, chlorophyll >1350 µg·mL⁻¹).

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Growth Response of *Salix nigra* Marsh. to Fertilization, Humate Additive, and Mycorrhizae Inoculation in a CU Soil Container Study

Jason Grabosky¹ and Nina Bassuk²; ¹Dept. of Environmental Horticulture, Univ. of Florida, Gainesville, FL 32611-0670; ²Cornell Univ., Dept. of Floriculture Ornamental Horticulture, Urban Horticulture Institute, Ithaca, NY 14853

CU soil is a material primarily composed of clay loam soil and crushed stone designed for use under pavement to promote street tree root growth in a durable pavement section, such as sidewalks or parking lots. One concern is the low total soil fraction from which tree roots can meet nutritive demands. At issue is the long-term nutrient management of street trees once the root zone has been rendered inaccessible due to the pavement wearing surface, although in 3-year field tests, there were no differences found between a CU soil material and an agricultural field control. CU soil treatments were produced in a fractional factorial design with a patent applied for, processed humate additive, a nursery production fertilization treatment, and a mycorrhizae inoculation package of Pt and various VAM species. The mycorrhizae/fertilizer treatment was eliminated for plant availability restrictions. Bare-root seedlings of *Salix nigra* Marsh. were grown in treatment containers for 5 months. A Minolta SPAD-502 was used to evaluate relative chlorophyll content as an indication of leaf tissue nutrient levels. Plant growth as a function of root dry weight, shoot dry weight, and shoot : root ratio was analyzed. Soil analyses were conducted on media samples collected at the end of the study to evaluate the impact of humate admixes in nutrient availability. The fertilization treatments positively influenced leaf color, shoot weight, root weight, and shoot : root ratio. There was no impact from the mycorrhizae inoculation on leaf color or growth. There was no impact from the humate additive on leaf color or growth. There were no additive effects found in the treatment levels.

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Fine Root Turnover and Mycorrhizal Morphotypes in Loblolly Pine (*Pinus taeda* L.)

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Loblolly pine (*Pinus taeda* L.) is the most widely planted tree species in the Atlantic Coastal Plain. To maximize its aboveground yield, it is vital to understand how root production, particularly fine root production, affects root carbon allocation to its root systems under various environmental conditions. Over a 2-year period (1998–99), we conducted a field study using minirhizotron technology to investigate fine root production and turn over in four families of a 6-year-old loblolly pine stand in Scotland County, N.C. A total of 144 minirhizotron tubes were installed to examine potential genetic differences in fertilizer effects on fine root turnover. Data analyses indicated an interaction between these families and fertilizer treatments for total fine root length and total fine root number. The effect of treatment on total root length was less clear in the faster-growing families. However, fertilization increased total root length in a slow-growing family but decreased total root length in a faster-growing family. Total root number was decreased by fertilizer treatment in the two fastest-growing families, but increased in the two slowest-growing families. Because ectomycorrhizae are significant carbon sinks in pine root systems and more than 90% of short roots in these loblolly pine families were colonized, ectomycorrhizal short roots (clusters) were classified into nine different morphotypes. No treatment and family interactions were found. Fertilizer treatment decreased the number of mycorrhizal clusters per unit root length. Dark and brown morphotypes were dominant mycorrhizal morphotypes among all the families. Our results suggest possible genetic differences and treatment effects on root system carbon demands of loblolly pine.

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The Relationships among Preceding Air Temperatures, Cold Hardiness, and Water Content of Concord Grape Canes from Fall to Early Spring

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Biweekly cold hardiness and water content were measured on 1-year-old field cuttings of bearing Concord grapevines at the Horticultural Teaching and Re-

search Center at MSU from Sept. 1998 to Apr. 1999. Cold hardiness index LT₅₀ (temperature at which 50% of the sample was killed) was determined by three viability tests after laboratory controlled sub-freezing treatments. Weather data were obtained from the MSU agricultural weather automatic system. Average maximum and minimum air temperatures of 1, 3, 5, and 7 days prior to each field sampling were regressed against the LT₅₀ of the tissues. Our results suggested that: 1) T_{min1} (minimum air temperature of the preceding 1 day of each sampling) had the most significant correlation with LT₅₀ and cane water content among all air temperatures analyzed. 2) While cane water content was significantly related to its bark water, the water content of periderm and pith did not. 3) When comparing the effects of T_{min1} and bark water content on cane LT₅₀ together, bark water had significant higher coefficient of determination (R²). This research provided additional information about the mechanisms of plant dormancy and cold hardiness.

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Sexual and Vegetative Performance of Native and Cultivated Day-neutral Strawberries under Moderate and High Temperatures

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A common complaint with day-neutral strawberries is that they perform poorly in mid-summer heat. Since most modern day-neutral cultivars are derived from the same *Fragaria virginiana* ssp. *glauca* clone from Utah, we felt it prudent to search for alternate sources of day-neutrality that were more heat-tolerant. We compared the sexual and vegetative performance of nine *F. virginiana* clones from a wide range of environments including the Utah site, and four *F. x ananassa* day-neutral types ('Aromas', 'Fort Laramie', 'Ogallala', and 'Tribute') under constant temperatures of 18, 22, 26, and 30 °C and 12-h days. 'Aromas' and 'Tribute' carry the Utah source of day-neutrality, while 'Fort Laramie' and 'Ogallala' are old cultivars that have a different, complex background. After a 4-week period of acclimation, we counted the number of crowns, inflorescences, flowers, stolons, and daughter plants that emerged over a 10-week period, and measured the dry weights of component parts. ANOVA tables revealed that temperature regime (T), genotypes (G), and T*G were significant for flower number (FLN) and total dry matter accumulation, while species and T*G were significant for daughter plant number (DPN). Mean FLNs across the four temperatures were 6.8, 3.7, 3.3, and 1.2, while mean DPNs were 0.7, 0.9, 0.7, and 1.8. *F. virginiana* clones averaged 3.8 FLNs and 1.8 DPNs, while the *F. x ananassa* clones averaged 4.1 FLNs and 0.2 DPNs. There was generally more variability among the *F. virginiana* clones than the *F. x ananassa* clones, but the *F. x ananassa* cultivars, 'Fort Laramie' and 'Ogallala', performed best at 30 °C. The Wasatch clone did not flower in any treatment, suggesting it is not day-neutral.

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Growth of Grapevines With and Without Grow Tubes

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Grapevines (cv. Steuben) were field-grown for 1 year to determine the effects of pruning and grow tube use on vine growth. Plots were grown on Crosby-Miami silt loam soils, trickle irrigated as needed to ensure adequate moisture, and provided a 3-ft band of weed control on each side of the row. Vines were trained onto a 5-ft. tall-trellis using the following techniques: 1) pruned to a single shoot and placed in a grow tube supported by a bamboo stake, 2) pruned to a single shoot and trained on a bamboo stake without a grow tube, or 3) left unpruned and trained on four strings radiating out from the vine to the top wire. At the end of the growing season, the vines were destructively sampled for leaf area, total shoot growth, average internode length, shoot diameter, top growth dry weight, and root system dry weight. The results indicate that pruning vines to a single shoot significantly reduced overall vine growth, whether a tube was used or not. Vines trained to single shoots and grown with or without grow tubes did not differ significantly for the various parameters measured. Unpruned vines produced nearly three times more leaf area, more than two times more total shoot length, and more than two times more top dry weight and root dry weight than the other treatments. A sub-set of these vines will be grown for one more season to determine if the negative effects of pruning and/or tubes will effect vine size after a second season.

Effect of STC-4771, An Intermediate of ABA Synthesis, on the Anthocyanin Accumulation in Grapes

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The coloration of grape berries depends on the anthocyanin synthesis during maturation. The quality of berries is often decreased due to the poor color development when berries are grown under unfavorable environments and/or inadequate internal factors are involved. It has been well-known that the level of ABA at ripening is closely associated with anthocyanin synthesis; thus, the external application of ABA results in the increase of anthocyanin content even in berries grown under favorable conditions. However, the agricultural use of natural ABA is not possible because of high prices. This experiment was conducted to study the potential of STC-4771 as a substitute for ABA. The effect of STC-4771 was studied in 'Kyoho', 'Pione', and 'Delaware' grapes. Chemicals were applied when $\approx 10\%$ of berries in a cluster were colored. In 'Kyoho', anthocyanin synthesis was enhanced at a concentration of 100 mg/L and there was a trend in color enhancement in 'Pione', regardless of treatment concentration, between 10 to 40 mg/L. However, no clear effect was found in 'Delaware' at 50 to 100 mg/L. In an in vitro experiment, anthocyanin was only increased when an adequate amount of sucrose (0.6 M) was added in the incubation medium under light. Natural ABA effectively increased the anthocyanin content of berry segments even under shading condition through four bagging materials, but no effect was confirmed in STC treatment.

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Possible Involvement of Polyamines in Floral Stimulus in Springbearing Strawberries

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A prevailing hypothesis indicates that a decrease in vegetative growth and cessation in floral initiation in strawberry in response to changes in photoperiod and temperature may correlate with hormonally induced changes. We investigated changes in endogenous free polyamines in crowns, flowers, leaves, and fruit of springbearing strawberries (*Fragaria xananassa* cvs. Chandler and Earliglow) in response to varying temperatures to induce flowering. Spermidine was the prominent free amine in crowns. No marked changes of putrescine, spermidine, and spermine were observed in crowns during the transition from vegetative to reproductive growth in either cultivar. In contrast, high levels of free polyamines were noted in young developing tissues such as the most recently initiated leaves, flower buds, and green fruit. When the putrescine synthesis inhibitor difluoromethylornithine (DFMO, 1 mM) was exogenously applied, levels of putrescine, spermidine, and spermine were altered in crown tissues in greenhouse experiments. These findings indicate that free polyamines may potentially be associated with the stimulation of new growth in springbearing strawberries under the present experimental conditions evaluated.

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Training System and Photosynthetic Activity of 'Perlette' Vines Grown in the Sonoran Desert

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Table grapes grown in the Sonoran Desert of Mexico are mostly an export commodity directed to early season markets. In order to define the effect on canopy management on light use and berry ripening, 'Perlette' vines planted along east-west rows (typical in such a region) were trained under four systems: slanted pergolas (SP), CIAD, lyre (LY), and T-trellis with open canopies (TTOC). They were compared with traditional closed-canopy T-trellis (TT). Variables evaluated were photosynthetic active radiation (PAR), photosynthesis (PH), stomatal resistance (SR), chlorophyll content (CC), and berry total soluble solids (TSS). At harvest, PAR values for LY, SP, CIAD, TTOD, and TT were 2192, 2076, 1900, 885, and 771 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, respectively. In the same order, PH at veraison was 12.5, 12.7, 11.0, 10.5, and 5.1 $\mu\text{mol CO}_2/\text{m}^2$ per s, while in recently harvest vines it decreased to 9, 8.1, 5.1, and 3.7 $\mu\text{mol CO}_2/\text{m}^2$ per s. SR at veraison was 3.4, 2.6, 2.8, 3.9, and 4.2 s/cm, but, after harvest it was 2.5, 3.5, 2.3, 2.9, and 6.8 s/cm. No significant differences in CC were found among treatments. TSS on 27 Apr. reached 14.9, 15.3, 15.7, 14.5, and 12.2 °Brix; on 29 Apr. they increased to

15.9, 15.5, 16.3, 15.1, and 13.1 °Brix. Based on the above, we demonstrated that canopy management and sunlight cropping represent a useful tool to advance table grape ripening, thus allowing an early harvest and therefore access to the high prices typical of early season markets.

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Comparison of Spinach Growth and Development Under Broad- and Narrow-spectrum Lighting Sources

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Various electric lamp sources have been proposed for growing plants in controlled environments. Although it is desirable for any light source to provide as much photosynthetically active radiation (PAR) as possible, light spectral quality is critical in regard to plant development and morphology. Light-emitting diodes (LEDs) and microwave lamps are promising light sources that have appealing features for applications in controlled environments. Light-emitting diodes can illuminate a narrow spectrum of light, which corresponds with absorption regions of chlorophyll. The sulfur-microwave lamp uses microwave energy to excite sulfur and argon, which produces a bright, continuous broad-spectrum white light. Compared to conventional broad-spectrum sources, the microwave lamp has higher electrical efficiency, and produces limited ultraviolet and infrared radiation. Experiments were conducted with spinach to test the feasibility of using LEDs and microwave lamps for spinach production in controlled environments. Growth and development comparisons were made during 28-day growth cycles with spinach grown under LED (at various red wavelengths), microwave, cool-white fluorescent, or high-pressure sodium lamps. Plant harvests were conducted at 14, 21, and 28 days after planting. At each harvest under all broad-spectrum light sources, spinach leaf growth and photosynthetic responses were similar. Major differences were observed in terms of specific leaf area and weight between spinach plants grown under 700 and 725 nm LEDs as compared to plants grown under shorter red wavelengths.

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Effects of CO₂ Enrichment on the Growth and Stomatal Conductance of Two Cultivars of Bean (*Phaseolus vulgaris* L.)

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Bean (*Phaseolus vulgaris* L.) cv. Etna, a dry bean variety, and cv. Hystyle, a snap bean variety, were grown at 400 and 1200 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ CO₂ to determine the effects of CO₂ enrichment on plant growth and stomatal conductance. Plants were grown in controlled environment chambers for 70 days at each CO₂ level using nutrient film technique hydroponics. An 18-h light/6-h dark photoperiod was maintained for each test, with a corresponding thermoperiod of 28 °C/24 °C and constant 65% RH. Diurnal stomatal conductance measurements were made with a steady-state porometer at 28 days after planting (DAP) and 49 DAP. As expected, plant growth and yield was consistently increased for each cultivar when plants were grown at 1200 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ CO₂ compared to 400 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ CO₂. Stomatal conductance measured during the light period showed an expected decrease for each cultivar when grown at 1200 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ CO₂ compared to 400 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ CO₂. However, during the dark period, stomatal conductance was higher for each cultivar grown at 1200 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ CO₂. These results suggest a stomatal opening effect in the dark when plants are exposed to enriched levels of CO₂. Tests are underway to investigate the effects of CO₂ levels greater than 1200 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ on the growth and stomatal conductance of bean.

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Elongation of Asparagus Spears Throughout a Spring Harvest

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Daily and total elongation of spears, plus elongation rates, and the number of days to reach maximum height of spears prior to branching were measured on 5-year-old asparagus plants of cultivars Atlas, Ciprés, Gijnlim, Jersey Giant, JWC1, UC-157 F1, and UC-157 F2. Six measurement periods were carried out every other week during a spring harvest, measuring spears from emergence to maximum height before branching (5 mm of branch above budscale). Daily elongation varied widely through harvest, from less than 1 cm/day when average tempera-

tures were below 10 °C, to more than 14 cm when daily temperatures reached a mean between 16 to 18 °C. Total spear length varied from an average of 50 cm, at the beginning of spring, to an average of 32 cm at the end of spring. Elongation rates varied between and within periods: less than 1cm/day at the beginning of the season to more than 15 cm/day at the end of the season; within a given period lower rates prevail at start of elongation. Days to reach maximum height varied from up to 13 days, at the beginning of the season, to 5 days at the end of the harvesting period. Cultivars showed somewhat similar elongation patterns; however, variations observed could have significant effects on quality and total commercial yield of spears.

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Influence of Irrigation Levels and Application Moments on Growth and Performance of an Early Sweetpotato Cultivar

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The objective of this work was to establish the dry-matter production and yield at different irrigation levels and moments of water application. An early cultivar, INIA-Sandu, was transplanted in Nov. 1996. Treatments were a combination of: no irrigation, irrigation at 25 kPa and 75 kPa of soil moisture tension during the first 60, 30 to 90, 60 to 120 days, and during all the cycle after crop establishment. Sequential samples were done throughout the growth cycle. The parameters evaluated were fresh and dry weight of leaves, stems, and roots. At the end of the crop cycle, yield was determined. Irrigation levels and early applications affected weight of leaves, stems, and roots. Yield was greater at early water applications during the growth cycle. Lower soil moisture tensions tend to have greater yields.

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Scarification and Moisture Effects on Triploid Watermelon Seed Germination

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Triploid watermelon [*Citrullus lanatus* (Thunb.) Matsum & Nakai] consumption is increasing in the U.S. However, some of the original problems, poor and inconsistent germination, still exist. Seeds of several triploid and diploid watermelon cultivars were subjected to a variety of treatments to improve germination. Control and scarified seeds, by nicking, were incubated at 25 or 30 °C in either 5 or 10 mL H₂O or hydrogen peroxide (H₂O₂). Triploid seed germination was strongly inhibited in all cultivars when seeds were at 10 mL of the H₂O or H₂O₂; both nicking and H₂O₂ increased germination, but not equal to rate of the control in 5 mL H₂O or H₂O₂. Germination of diploid cultivars was unaffected by any treatment. Seed morphological measurements indicated that triploid seed has a smaller embryo with a large and highly variable (CV = 105%) air space surrounding the embryonic axis as compared with the diploid seed. These data suggests that triploid watermelon seed germination is not inhibited by the seedcoat thickness alone. Seed moisture plays a significant role in germination, emergence, and stand uniformity.

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Non-destructive Surface Area Determination of Vegetables

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Surface area of cucumbers, carrots, parsnips, and beets was determined using the following non-destructive methods: Baugerod's method, Baugerod's method with inclusion of a factor correcting for substitution of weight for volume in the formula, and a novel image analysis method. Accuracy of the methods was ascertained by comparison with a direct shrink-wrap replica method of surface area measurement. Vegetables ranged in shape from cylindrical (cucumber and carrot) to conical (parsnip and beet). No difference in accuracy among methods of surface area determination was detected for carrots or beets. Baugerod's method and the image analysis technique differed significantly from the direct shrink-wrap replica technique for surface area determination of parsnips and cucumbers, respectively. Inclusion of a correction factor in Baugerod's method did not increase the accuracy of this method for any of the vegetables. The precision and repeatability of each method was determined by repeated measures analysis. Baugerod's method lost precision and repeatability for the conically shaped vegetables. Conversely, the shrink-wrap replica method lost precision and repeatability for the cylindrically shaped vegetables. The image analysis technique was precise and highly repeatable over the range of vegetable shapes. The develop-

ment of a rapid, accurate, and precise non-destructive method of surface area measurement using image analysis techniques will provide a useful tool in the physiological study of vegetable products. Applicability of such a method over a range of vegetable shapes will be of additional value.

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Growth, Gas Exchange, and Water Relations of Micropropagated Chile Ancho Pepper (*Capsicum annuum* L. cv. San Luis) Plantlets during Acclimatization and Post-acclimatization

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Micropropagated chile ancho pepper (*Capsicum annuum* L. cv. San Luis) plants were transferred to ex vitro conditions to study plantlet performance and selected physiological changes that occur during acclimatization and post-acclimatization. The physiology of the plantlets was characterized by measuring leaf gas exchange and water status. Plant growth was determined by assessing plant height, leaf number, total leaf area, relative growth rate (RGR), and leaf, root, and stem dry mass. Measurements were taken at 0, 1, 2, 3, 6, 12, and 24 days after transplanting. After initial transplanting ex vitro to liner pots with soilless media, plantlet wilting was observed that correlated with reduced leaf relative water content (RWC). Water stress was partially alleviated by a reduction in stomatal conductance (g_s), confirming that the in vitro formed stomata were functional and able to regulate transpiration (E) to minimize desiccation losses. Because of this stomatal control, plantlets had minimal transplant shock, recovered, and survived. Prior to transplanting, micropropagated plantlets showed heterotrophic/mixotrophic characteristics as indicated by low photosynthesis [(A) 4.74 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$]. During acclimatization, RWC, g_s , E, and A were significantly lower 2 days after transplanting. However, within 6 days after transplanting, plantlets recovered and became autotrophic, attaining high A (16.3 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$), g_s , and E. The stabilization and improvement of plantlet water status and gas exchange during acclimatization and post-acclimatization closely correlated with dramatic increases in plantlet growth.

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Mycorrhizal Enhancement of the Physiology and Growth of Micropropagated Chile Ancho Pepper (*Capsicum annuum* L. cv. San Luis) Plantlets during Acclimatization and Post-acclimatization

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The role of mycorrhiza fungi during acclimatization and post-acclimatization of micropropagated chile ancho plantlets was characterized through physiological and plantlet development changes. Regardless of mycorrhizal colonization, the pepper plantlets had initially low photosynthetic rates and poor growth following transplanting ex vitro. During the first days of acclimatization, water deficits occurred as evidenced by drastic reductions in relative water content. Consequently, transpiration rates and stomatal conductance (g_s) declined, confirming that in vitro formed stomata were functional, thus avoiding excessive leaf dehydration and plant death. Mycorrhiza had a positive effect on gas exchange as early as day 7 and 8, as indicated by increasing photosynthesis (A) and g_s . Mycorrhizal plantlets had reduced levels of abscisic acid (ABA) during peak stress (6 days after transplanting ex vitro), which corresponded with subsequent increases in g_s and A. During acclimatization, A increased in both non-colonized and colonized plantlets, with greater rates observed in mycorrhizal plantlets. During post-acclimatization, mycorrhiza colonized 45% of the roots of pepper plantlets and enhanced plant growth by increasing leaf area, leaf dry mass, and fruit number. Mycorrhiza also enhanced total leaf chlorophyll content, A, and nutrient uptake of pepper plantlets, particularly N, P, and K. Early mycorrhizal colonization produced important benefits, which helped ex vitro transplanted plantlets recover during acclimatization and enhance physiological performance and growth during post-acclimatization.

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Physiological and Anatomical Evaluation of Chilling-tolerant Sweetpotato Genotypes

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Selected physiological and anatomical characteristics of four chilling-tolerant sweetpotato genotypes were evaluated. Although the genotypes were considered highly tolerant to chilling, it was proposed that differences in their mechanism for tolerance existed. A genotype temperature interaction for chlorophyll fluorescence ratio was observed when the plants were exposed to 5 °C. Genotype differences were found for electrolyte leakage and peroxidase activity. There were no differences found for fatty acid percentage composition of the glycolipid or the phospholipid fraction from leaf samples. There were no differences in diffusive resistance and transpiration rate among the genotypes; however, stomata density, leaf shrinkage, and specific leaf weight differed among the genotypes. Differences were also found among the genotypes for percent leaf dry weight, leaf thickness, and cellular structure of the leaf. It was concluded that the basis or mechanism for chilling tolerance was not the same for the four genotypes tested; therefore, combining traits for tolerance could lead to higher tolerance levels.

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Influence of Lettuce Growth with High Temperature and Low Solar Radiation Conditions

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When we grow lettuce in the hot season in Japan, lettuce heads sometimes grow abnormally. In early autumn, we frequently find strange shapes of lettuce because of a projecting leaf midrib. Poorly shaped lettuce is unmarketable. We found that lettuce grew abnormally under the high temperature and low solar radiation conditions at the time of 1200 °C accumulative temperature from seeding (average temperature was >20 °C and daily total solar radiation was under 18 MJ/m²). Midribs of both good-shaped (resistance of projecting midrib) and poorly shaped cultivars projected this condition, but the symptom of the former was milder than that of the latter. So, we investigated the difference of leaf growth between good and poorly shaped cultivars using growth chambers. We set up six patterns of environmental conditions, which consisted of three patterns of temperature (30/22 °C, 24/16 °C, and 18/10 °C) and two patterns of light (4 and 2 MJ/m²). The two- to three-leaf seedlings, which were grown in the greenhouse for 27 days after sowing, were transplanted in the 250-mL pots and were carried to growth chambers. We measured width and length of each leaf 9 days after planting. Consequently, the ratio of width to length (w:l) of new leaves became low when we grew lettuce in high temperature or low light conditions. The w:l of good-shaped cultivars were higher than that of poorly shaped cultivars. Good-shaped cultivars did not grow spindly with ease on high temperature and low light conditions, like an early autumn environment. Now we will try to investigate the relationship between leaf shape and head shape on the poorly shaped conditions of some lettuce heads.

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Effects of Salt and Water Stress on the Growth and Photosynthesis Rate of Bell Pepper (*Capsicum annuum* L.)

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Salt and water stress affect in a significant way most common horticultural crops in northwest Mexico, where bell pepper, hot pepper, and tomato are the most important vegetable crops. Growth rate (GR) and physiological traits in bell pepper were analyzed under salt and drought stress. Two cultivars of bell pepper, 'Hungarian Yellow' (HY) and 'Sta. Fe Grande' (SG), were evaluated. GR in both cultivars was decreased by salt and drought stress interaction. Salt concentration in the irrigation water affected the amount of dry matter in the plant tissue. Relative growth ratio (RGR), net assimilation ratio (NAR), leaf area ratio (LAR), and photosynthesis rate (P_n) decreased in a correlated amount to the salt NaCl content in the experiment (0, 80, and 160 mM). Differences in the RGR under salt and drought stress between SG and HY were significant. The observed decrease in RGR was explained by NAR and LAR, where RGR was more affected by NAR than LAR. Similarly, the decrease in NAR was explained by C/F and P_n , indicating that NAR was more affected by P_n than C/F. The difference in observed NAR between both cultivars was understood by difference in C/F. Finally, a high relation of C/

F in SG cultivar under salt and drought stress was caused by a physiological use of photosynthetic products, causing a significant decrease in NAR in the cultivar HY. This difference in NAR was found to be the factor that affected RGR in both cultivars.

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Storability of Dry-heat-treated Gourd Seeds

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Even though dry-heat (DH) treatment has been widely used for inactivation of seed-borne virus in vegetable seeds, it is known that the seeds should be used within a year after the DH treatment because of the significant reduction of storage capability in DH-treated seeds. DH-treated seeds exhibited poor early germination and significantly higher percentages of abnormal seedlings produced. The final germination rate was, however, not usually influenced by DH treatment. DH-treated seeds had been stored at 20 °C up to 5 years in sealed containers with silica gel in some cultivars. Both the intact and DH-treated seed exhibited excellent germination even after 4 years of storage at room temperature. Even though the hypocotyl length was shortened in DH treated seeds of most cultivars tested, other characteristics of seedlings produced from intact and or DH-treated seeds were similar. Cultivars showed marked differences in seedling characteristics, especially in length of hypocotyles.

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WITHDRAWN

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Effects of Air Temperature and Carbon Dioxide Concentration on Growth of Radish

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The RASTA (Radish Assimilation in Spaceflight Testbed Atmospheres) space flight experiment is being designed to evaluate effects of spacecraft environment on carbon partitioning in radish. Carbon dioxide concentration and air temperature effects on radish partitioning are being evaluated to optimize conditions on orbit. Determining effects of these stresses on growth will allow environmental stress effects to be isolated from microgravity effects during the mission. Three cultivars, Cherriette, Cherry Belle, and Early Scarlett Globe, have been grown at 23 °C at 400, 1500 and 10,000 ppm CO₂ to determine effects of super-elevated CO₂ on growth. Total biomass production was greatest at 1500 ppm CO₂, with a decline at 10,000 ppm CO₂. Harvest index of all cultivars was also highest at 1500 ppm. 'Cherry Belle' and 'Early Scarlett Globe' were grown at ambient CO₂ under temperatures ranging from 18 to 30 °C. Total biomass production was greatest at 22 °C, with significant declines in total dry mass and harvest index with increasing temperatures. Temperatures less than 22 °C resulted in decrease in total biomass, but partitioning to storage roots was enhanced. (Supported by NASA NCC10-0034)

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Hydrogen Peroxide Reduces Hypoxia in Germinating Bean Seeds

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Effects of hypoxia on germinating bean seeds (*Phaseolus vulgaris* cv. Tendergreen) were examined by imbibing them in water for various lengths of time. Hypocotyl elongation under hypoxic conditions and recovery from hypoxia in bean seeds were determined. Oxygen concentration in the water began to decrease sharply after 12 h of seed imbibition and had declined by more than 63% after 3 days of seed imbibition. When seeds were germinated on 0.8% agar after 24 h of imbibition, the hypocotyl elongation was reduced by about 70% compared to the seeds with no hypoxia, and longer imbibition resulted in poor or no germination. Exogenous hydrogen peroxide (20 mM) in water increased the oxygen concentration from 250 to 350 mM in the presence of seeds and was considerably higher after 3 days of seed imbibition than that in the control. Hypocotyl elongation occurred in seeds submerged in water containing hydrogen peroxide up to 72 h while none was observed in water. This was comparable to hypocotyl elongation under non-hypoxic conditions. Hypoxia in imbibing seeds was overcome by the high oxygen levels in the medium resulting from reaction of hydrogen peroxide with seed catalase and catalytic metal ions. Considerable catalase

activity was detected in germinating seeds and the use of a catalase inhibitor, aminotriazole, suggests that the enzyme plays an important role in the release of oxygen into the medium. Of the catalytic metals, the seed content of iron was dominant and was about 6 folds higher than that of either copper or manganese.

215 Influence of Promalin Spray and Drench on Fern Numbers of Asparagus

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Asparagus (*Asparagus officinalis*) plants were sprayed and drenched with different concentrations of Promalin (0, 250, and 500 ppm) The varieties for the spraying experiment were 'Mary Washington', 'Emeral', 'UC-157-F1', and 'UC157F2'. Six replications for each treatment were used in a randomized complete-block design. The drenching experiment used two varieties (Mary Washington and UC-157-F2) with six replications of each treatment in a randomized complete-block design. Pots were numbered and labeled for each experimental unit. Plants (ferns) were counted and recorded in order to obtain the initial number of ferns before or after the spraying or drenching. In the spraying experiment, the plants were sprayed to run-off using a hand sprayer whereas; in the drenching experiment, 1000 mL or 1 L of the solution was used to drench each plant. The response to the chemical was measured in two ways: weekly stimulation of emergence of new-shoots and percent increase in final number of shoots over the initial number. In the spraying treatments differences were not found among the treatments used. In the drenching experiment with 'Mary Washington' variety, a lower initial number of ferns at 250 ppm as compared to the 0 ppm of Promalin (8.82 to 13.00) was observed. Differences for 'Mary Washington' variety was not found for cumulative number of ferns on weeks 1, 2, and 3. However, the percent increase in number of ferns was higher for the 250 ppm as compared to the 0 ppm (174.55% to 78.14%). 'UC-157-F2' showed no difference among the different concentrations. This indicates a difference in varietal response.

216 Carbohydrate and Alliin Concentrations in Garlic Produced under Different N Fertilization and Irrigation Regimes

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Garlic (cv California Late) was produced under four irrigation regimes (110% and 130% evapotranspiration with two water cut-off dates, 10 and 24 May 1999) in combination with three nitrogen fertilization levels (100, 250, and 400 lb total N). Bulbs were manually harvested mid-June, cured 3 weeks shaded at ambient temperatures and the outer whorl of cloves manually peeled. Samples were freeze-dried, and carbohydrate (fructan and free sugars) and alliin (substrate for alliinase activity and indicator of potential pungency) concentrations were determined by HPLC. The percent dry weight was not affected by the irrigation treatment, but was reduced with increased N rate (41.3% to 39.0%). Alliin concentrations varied from 8.3 to 13.8 mg/g DW for 110% and 130% E_t irrigation treatments. Alliin concentrations were not affected by N fertilization (average = 11.5 mg/g DW). Fructan concentrations were affected by N fertilization treatment, with the highest content (802 mg/g DW) associated with the lowest N level, and the lowest (717 mg/g DW) content in samples from the highest N rate. Sucrose concentrations increased with increased N, but glucose and fructose concentrations did not vary with N fertilization. Fructan as percent of total carbohydrate remained constant across irrigation treatments (96.6% + 0.2%) and across N fertilization treatments (96.6% + 0.3%).

217 Phytotoxic Effects of Different Insecticides, Doses, and Application Frequencies on Physiological Traits of Chili (*Capsicum annum* L.)

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The phytotoxic effects on the physiology of chili (*Capsicum annum* L. cv. Ancho San Luis) caused by four different insecticides were evaluated. Three commercial mixes (methyl azinfos, methyl parathion CE720, and metamidophos 600 LM), and an active ingredient alone (methamidophos) were assayed; water was used as the control. The main goal was to evaluate the insecticide effects on chili using four different doses; the mean dose, recommended on the label of the product

(R), a half one (1/2R), 1.5 times (1.5R) and twice the recommended dose (2R). Three frequencies of application were applied: once a week, twice a week, and once every other week, for 6 weeks from the beginning of flowering. Phytotoxicity was evaluated measuring the response of some physiological traits, Chlorophyll Fluorescence (CF), Leaf Temperature (LT), Transpiration (Tr), and Stomatal Resistance (SR). CF was measured by means of a portable chlorophyll fluorescence meter; LT, Tr, and SR were measured using a LI-Cor Porometer. The doses and frequencies used are all common in commercial chili fields in Mexico. Results showed that phytotoxicity caused by insecticides can be an important damage factor to the plants, something that can cause reduction of yields. CF was shown to be the most sensitive variable to evaluate the phytotoxicity caused by insecticides. Fruit malformation was observed in all treatments. Chlorophyll content was reduced up to 25%, on average. The phosphorate insecticides affected the physiological parameters more drastically than the others. Results evidence the irreversible crop damage caused by excessive insecticide applications.

42 POSTER SESSION 5 (Abstr. 218–249) Crop Production Monday, 24 July, 1:00–2:00 p.m.

218 Dissipation of Isoxaben in Simulated Gravel-based Nursery Runoff Retention Basins

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Recent research indicated that the herbicide simazine dissipated quickly in gravel-based subsurface-flow constructed wetlands. This indicates that retention areas at nurseries may be developed to facilitate pesticide remediation and reduce offsite movement. A site to simulate runoff retention areas at a containerized nursery was established with troughs containing pea gravel and controls containing no gravel in an open field. Irrigation water was applied daily to replace half of the capacity of the trough, simulating daily irrigation and runoff at a nursery. A study was conducted to determine the effects of this system on isoxaben (a pre-emergent herbicide) concentrations in the water leaving the troughs and the change in microbial organisms associated with the gravel. Initially, 19 L of a dilute isoxaben solution (1.3 µg/L) was added to each tank. Drainage was collected and assayed for isoxaben concentration over a 40-day period. Isoxaben was detected in troughs containing gravel through 14 days while isoxaben was detected in troughs containing no gravel through only 4 days. Microbial analysis of the gravel showed a variety of microorganisms initially, but, by day 14, *Pseudomonas* spp. became the dominant genus present. Preliminary analysis revealed that the isoxaben binds to the gravel, and is then desorbed over time. Further investigations will include the abilities of *Pseudomonas* and other isolated organisms to metabolize isoxaben as the sole carbon-source in the laboratory.

219 Alternative Weed Control Methods for Production of Large Container Ornamentals

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Non-target herbicide losses pose environmental concerns for nurseries. Therefore, the objective of this research was to determine the ability of each alternative mulch to suppress weed growth when compared to traditional chemical methods. Uniform quart liners of *Lagersroemia indica* x *faurei* 'Natchez' were planted in 15-gal containers 15 June 1999, on a gravel container pad using overhead irrigation. Weed pressure was uniform. Treatments include Regal 0-0 3 G (3 lb ai/a) as a broadcast or individual container application, recycled newspaper pellets (1 inch thick), Spin-out coated recycled newspaper pellets (1 inch thick) geotextile disks (Spin-out coated), kenaf mulch, waste tire crumbles, wheat straw (2 inches thick), oat straw (2 inches thick), cereal rye straw (2 inches thick), paper mill sludge (2 inches thick), a handweeded control, and a weedy control. Treatments were organized in a RCBD consisting of eight single-plant replicates. The geotextile disks, newspaper pellets treated with spin-out, and shredded rubber tire treatments all

had better than 80% weed control from 30 to 180 DAT. These alternative weed control methods can provide a good alternative to conventional weed control practices in large container-grown ornamental.

220

Growth of Evergreen Shrubs in Potting Mixes Made with De-inked Paper Sludge

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De-inked paper sludge from a newsprint mill was evaluated as a substitute for softwood bark in container media. Rooted cuttings of 'Youngstown' juniper (*Juniperus horizonallis*), Fraser photinia (*Photinia x fraseri*), and 'PJM' rhododendron (*Rhododendron*) were planted in 3-L plastic pots that contained potting media amended with 0%, 20%, 40%, 60%, 80%, or 90% paper sludge and 80%, 60%, 40%, 20%, or 0%, respectively, bark (by volume). All mixes contained 10% sand and 10% peatmoss except for the 90% mix, which lacked peatmoss. After 19 weeks, plant heights were measured for photinia and rhododendron, but average plant width was measured for juniper. Shoot dry weights were also determined for all species. Juniper and photinia seemed to be the most tolerant of media amended with up to 40% paper sludge, whereas rhododendron was the most intolerant species. Shoot dry weights of juniper or photinia were similar for plants grown in media containing 40% or less paper sludge. Shoot dry weights of rhododendron plants grown in 40% sludge were 23% lower than those grown in 0% or 20% paper sludge, which were similar to each other. Plant heights followed similar trends to those of the shoot dry weights. With the exception of juniper, shoot dry weights and heights were drastically reduced if the potting mixes contained more than 40% paper sludge. These results demonstrated that de-inked paper sludge could be substituted for up to 40% of the bark in a container medium for two of the three species tested.

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Preemergent Weed Control in Container-grown Herbaceous Perennials

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During the 1999 season, preemergent herbicides were applied to container-grown herbaceous perennials and evaluated on the basis of weed control, phytotoxicity, and effect on plant growth. The herbicides and rates were: Oxyfluorfen + Pendimethalin (Scotts Ornamental Herbicide II) 3 and 6 lb ai/A, Napropamide (G) (Devrinol) 3 and 6 lb ai/A, Oryzalin (Surflan) 2 and 4 lb ai/A, Oxadiazon (Ronstar) 4 and 8 lb ai/A, Oxyfluorfen + Oryzalin (Rout) 3 and 6 lb ai/A, Prodiamine (Barricade) 0.65 and 1.3 lb ai/A, Pendimethalin (Scotts Ornamental Weedgrass Control) 2 and 4 lb ai/A, Trifluralin (Treflan) 4 and 8 lb ai/A. Herbicides were applied to *Penstemon mexicali* 'Red Rocks'™, *Osteospermum barberiae compactum* 'Purple Mountain'™, *Gazania linearis* 'Colorado Gold'™, *Agastache rupestris*, *Diascia integerrima* 'Coral Canyon'™, and *Zauschneria arizonica*. All plant and herbicide combinations did not result in any significant decline in plant growth. All herbicides provided good weed control.

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Energy Balance of Six Common Landscape Surfaces

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Growth of woody landscape plants is strongly affected by the underlying surface. In urban areas, plants are subjected to energy balance characteristics of a variety of surfaces. This research investigated energy balance properties of six common urban surfaces: Kentucky bluegrass, pine bark mulch, concrete, asphalt, lava rock mulch, and gravel rock mulch. Each summer over a 2-year period incoming global radiation (GW), relative humidity, and air temperature were measured over each surface, and surface reflectivity (AW), surface temperature (TS), soil temperature (TO), and soil heat flux (SF) were measured below each surface. Thermal conductivity (K) and emitted surface longwave radiation (LW) were also calculated. Surface property differences were determined by regression analysis. Incoming global radiation (independent variable) versus TS, TO, SF, LW data (dependent variable) were analyzed. Linear or quadratic curves were selected according to significance of each variable and the coefficient of determination (R²). Surface reflectivity was greatest for concrete and least for lava rock mulch, and K

was greatest for asphalt and concrete and least for lava rock and pine bark mulch. Under maximum GW, regression data indicate that SF and TO would be greatest under asphalt and least under lava rock and pine bark mulch. Under similar circumstances, TS and LW would be greatest for pine bark mulch and least for Kentucky bluegrass. This research revealed that more energy was conducted into the soil below asphalt and concrete, and that a greater portion of GW was prevented from entering the soil below pine bark and lava rock mulch than below other surfaces. Due to these effects, and the lack of evaporative cooling, surface temperatures were greater, and more longwave radiation was emitted from, non-vegetative surfaces than from turf.

223

Precipitation Evaluation of Round- and Square-patterned Impact Sprinklers

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Two impact sprinklers, a traditional round-patterned design (Rain Bird Maxi-Bird) and a newly developed square-patterned design (Square Shooter) were tested under field conditions to compare the uniformity of their precipitation patterns. The Square Shooter sprinkler requires half as many sprinkler heads as the Rain Bird to cover the same area with head-to-head coverage. The Square Shooter sprinkler, with a coefficient of variation of 0.124, produced a more-uniform distribution of precipitation than the Rain Bird sprinkler, with a coefficient of variation of 0.215. Square Shooter also delivered water more accurately within the boundaries of the plot than Rain Bird, which had more of the total precipitation falling outside the plot area than Square Shooter. The new square-patterned design could allow installation of heads on only one edge of an area with the same, or better, uniformity of coverage as traditional perimeter installations.

224

Influence of Early Harvest PGR on the Growth of Five Ornamental Species

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Decline of certain container-grown ornamental species during the hottest months of summer is a common problem for nurserymen in the southeastern United States. When roots are killed due to high root-zone temperatures and growth ceases, production of plant hormones also decreases. A study was conducted with Early Harvest PGR (Griffin LLC, Valdosta, Ga.), which contains cytokinins, gibberellic acid, and indole butyric acid, to determine if this product would improve the growth of five ornamental species that typically decline during the summer in south Georgia nurseries. The species used were *Cotoneaster dammeri* Schneid. 'Coral Beauty', *Cotoneaster salicifolius* Franch. 'Green Carpet', *Spiraea japonica* L. 'Shirobana', *Thuja occidentalis* L. 'Little Giant', and *Weigela florida* (Bunge) A. DC. 'Minuet'. The treatments (control, 1.5 and 3.0 mL Early Harvest PGR/1125 mL water) were applied every 2 weeks from mid-June until mid-Sept. 1999 as a foliar drench. Treatment of both *Cotoneaster* species and the *Thuja* with Early Harvest PGR resulted in little influence on plant growth. While growth indices did not increase, shoot dry mass of *Spiraea* and *Weigela* increased 17% and 26%, respectively, when treated with Early Harvest PGR at the medium rate. Plant quality ratings for *Spiraea* increased when the 1.5-mL rate of Early Harvest PGR was applied. A rate of 3.0 mL of Early Harvest PGR on *Spiraea* decreased shoot and root dry mass, total biomass, root ratings, and final plant quality. Root ratings and plant quality were highest for *Weigela* grown with the 1.5-mL Early Harvest PGR treatment. These results indicate that treatment of woody ornamentals with Early Harvest PGR for positive results is both species- and rate-dependent.

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Growth and Aesthetic Evaluations of Container- and Field-grown Atlantic White Cedar, *Chamaecyparis thyoides* (L.) B.S.P.

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Fifty-four taxa of Atlantic white cedar [*Chamaecyparis thyoides* (L.) B.S.P.] were assembled and maintained. A protocol for propagation of Atlantic white cedar was established. Plants were grown in containers and in a replicated field plot. Height and width data were recorded from container- and field-grown plants and all taxa were evaluated for growth habit, growth rate, and summer and winter color. Color descriptions of foliage are provided based on the Royal Horticultural

Society colour chart. Exceptional taxa were identified based on needle color, texture, growth habit, and growth rate. Superior green forms include Dirr Seedlings 1 and 2, 'Emily', 'Rachel', and 'Okefenokee'. The superior variegated form is 'Webb Gold'. Superior blue forms include 'Blue Sport', 'Glaucula Pendula', and 'Twombly Blue', and superior slow-growing forms include 'Andelyensis', 'Meth Dwarf', 'Red Star', and 'Heatherbun'. These taxa are recommended to growers, landscapers, and gardeners for production and use.

226

Juvenile and Adult Growth Characteristics of Newly Planted *Euonymus fortunei* 'Coloratus'

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Euonymus fortunei 'Coloratus' (Turcz.) Hand.-Mazz. (purpleleaf wintercreeper euonymus) is a groundcover species commonly grown in the landscape and known for its characteristic purplish-red color in the fall. This species is dimorphic, having both juvenile and adult forms present in established plants. Young plants, planted from 5.7-cm containers, were grown under full sun and 60% shade and evaluated for 1 year from May 1998. Four fertilizer treatments, up to four applications, were applied over the year. Data collected included the percent of adult and juvenile plants per plot, percent canopy cover, plant quality, and fresh and dry weights of pruned plant material and whole plants. Results showed that 73% of *Euonymus* planted in the shade were "adult-like" in form, while only 44% of *Euonymus* planted in the sun were "adult-like" in form. These results were analyzed with the percentage canopy cover determined for March, April, and May 1999 and showed no interaction of the two variables. By the end of the study, the mean percent of canopy cover was 77% under the shade and 74% under the sun. These values were not significantly different. While it appeared that the maturity of the plant did not effect the percent of groundcover coverage in a plot, the more mature or "adult-like" plants were visually undesirable within a plot of juvenile plants, and vice versa due to morphological differences.

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Rate of Root Growth of Three Woody Ornamental Species

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Root growth is a critical factor in landscape establishment of container-grown woody ornamental species. *Kalmia latifolia* (mountain laurel) often does not survive transplanting from containers into the landscape. The objective of this experiment was to compare rate of root growth of mountain laurel to that of *Ilex crenata* 'Compacta' ('Compacta' holly) and *Oxydendrum arboreum* (sourwood). Six-month-old tissue-cultured liners (substrate intact) of mountain laurel, 1-year-old rooted cutting liners (substrate intact) of 'Compacta' holly (liner holly), 6-inch bare root seedling liners of sourwood, and 3-month-old bare-root rooted cuttings of 'Compacta' holly were potted in containers in Turface®. Prior to potting, roots of all plants were dyed with a solution of 0.5% (w/v) methylene blue. Plants were greenhouse-grown. Destructive harvests were conducted every 2 to 3 weeks (six total harvests). Length, area, and dry weight of roots produced since the start of the experiment, leaf area, and dry weight of shoots were measured. Sourwood and liner holly had greater rate of increase in root length and root dry weight than mountain laurel and bare root holly. Rate of increase in root area was greatest for sourwood, followed by (in decreasing order) liner holly, mountain laurel, and bare-root holly. Increase in root length and root area per increase in leaf area was highest for liner holly, possibly indicating why this species routinely establishes successfully in the landscape. Increase in root dry weight per increase in shoot dry weight was lowest for mountain laurel. The slow rate of root growth of mountain laurel (compared to sourwood and liner holly) may suggest why this species often does not survive transplanting.

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Considerations for the Nursery Production of the Ornamental Grass *Hakonechloa macra* 'Aureola'

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Studies conducted in 1998 and 1999 analyzed the influence of division size, nutrition, and potting medium pH on the growth rate of *Hakonechloa macra* 'Aureola' in nursery-container production. For each study, divisions were made from container-grown nursery stock in late March, then established in 325-mL pots in

a greenhouse prior to being transplanted to 3.7-L nursery containers in late May. Grass plants were grown outdoors, under 30% shade density cloth, with drip irrigation from June through September, and, excluding plants in the nutrition study, received top-dressed 17–6–10 slow-release fertilizer containing micronutrients. To determine the optimum division size for production, divisions of four sizes were made (based on one to two, four to six, eight to 10, or 12 to 15 buds per plant). There was a significant division size effect on bud count, leaf area, plant weight, width, and shoot count only when comparing the two lowest division sizes with the two highest. Treatment effects were insignificant among divisions containing one to two and four to six buds, or between eight to 10 and 12–15 buds. Both the larger two sizes produced marketable plants; therefore, divisions with eight to 10 buds are recommended for a schedule aimed at producing salable *Hakonechloa* over one growing season. The smallest division class is believed to be the more efficient size when one merely wishes to increase plant stock. In a separate study, a factorial trial testing ppm fertilizer (28, 56, 112, 224, and 448 ppm N) and N–P–K formulation (1–1–1, 2–1–2 and 4–1–4) did not generate significant differences between formulations. Plants were fertigated once a week, and EC levels were monitored bi-weekly from leachate collected in drainage saucers. Plant responses to N rates suggest that electrical conductivity levels be kept around 2.5 mS·cm⁻¹ from a 112 ppm N fertilizer (EC can go as high as 4.0 mS·cm⁻¹ with 224 ppm N). It was evident *H. macra* 'Aureola' prefers acidic soil in production. When lime was not included in the potting mixture (a control treatment equating to a pH of about 4.5), leaf area, bud count, and shoot number doubled relative to the three lime treatments (2, 6, and 16 g lime/L of media, or 3.4, 10.1, and 26.9 lb/yard³).

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Influence of Diploid Pollinizers on Seedless Watermelon Yield and Quality

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Due to the lack of viable pollen produced in seedless (triploid) watermelons, fruit set in seedless watermelons requires a standard seed (diploid) producing cultivar (hereafter referred to as a pollinizer) to be interplanted as a source of pollen. It is recommended that one row of pollinizer be planted for every two rows of seedless watermelon. There is little to no information available to growers comparing the effects of pollinizers on seedless watermelon yield and quality. We conducted a study to evaluate the effectiveness of three seeded pollinizers ('Crimson Sweet', 'Fiesta', and 'Royal Sweet') on yield and quality of four seedless watermelon hybrids ('Abbott and Cobb 5244', 'Crimson Trio', 'Millionaire', and 'Tri-X 313'). 'Royal Sweet' as a pollinizer tended to produce higher yields of small (<3.6 kg) and medium-sized seedless watermelons (3.6–7.3 kg) per acre compared to 'Crimson Sweet' and 'Fiesta'. 'Crimson Sweet' produced a greater number of large (>7.3 kg) seedless watermelons compared to 'Fiesta' and 'Royal Sweet'. However, the number of marketable melons (>3.6 kg) did not differ among the three pollinizers evaluated. Two quality measurements taken (hollow heart and soluble sugars) were not influenced by the choice of pollinizer.

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Evaluation of Two Commercial Formulations of Mycorrhizal Fungi for Honeydew Melon (*Cucumis melo* L.) Seedlings Production

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Use of arbuscular mycorrhizal fungi (MA) on horticultural plant production has great potential as a biotechnological alternative; however, information on its effects on the early growth phase of honeydew melon is lacking. Nevertheless, it would seem that inoculation at the time of sowing would decrease the stress of transplant, improve root vigor, make plants grow faster, improve drought resistance, and lessen the effect of roots diseases. In this study, we evaluated the effects of inoculating honeydew melon seedlings with two commercial formulations of MA fungi at different study times in an effort to select for higher resistance and infective capacity. 'Moonshine' hybrid melon seeds were sown in trials with 200 cavities containing specific doses of inoculate: 0, 100, 200, 250, 500, and 1000 cc/trial of BuRIZE, Mycorrhiza NES. A factorial design was used (formulations and study times) with a randomized distribution and four replications. Four destructive samples were taken at 10, 15, 20, and 25 days after inoculations. Number of leaves, shoot fresh weight, dry weight, root fresh weight, foliar area,

and mycorrhizal colonization were recorded. Results obtained showed a highly significant effect between commercial formulations and study times and an interaction of both factors to studied variables. Mycorrhizal colonization percentages were too low (0.3% to 1.7%). At 20 days after inoculations, it was possible to see all the components of functional arbuscular mycorrhizal symbiosis on melon plants roots. Using commercial formulations of mycorrhizal fungi decreased applications of fertilizers in melon plants.

231 Pollinizer Frequency for Optimum Fruit Production of Triploid Watermelons

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During 1998 and 1999, 'Genesis' triploid watermelons were grown in large blocks with a single row of the diploid 'Ferarrì' planted as a pollinizer in the middle. A once-over harvest of triploid watermelons was made each year in harvest lanes 0-, 1.5-, 3.0-, 4.5-, 6.0-, 7.5-, and 9.0-m perpendicular distances from the pollinizer row. Individual fruit were weighed and counted. Data from both years indicated a similar distribution of triploid fruit with respect to distance from the pollinizer row. The greatest number of triploid fruit per unit land area was in the harvest row 3.0 m from the pollinizer row. When distance from the pollinizer row was 6.0 m or greater, triploid fruit numbers diminished substantially. Yield estimations made each year using the fruit density data suggested that a 1 pollinizer : 4 triploid ratio gave the maximum total triploid fruit yield per hectare for 1.5-m row spacings. These results should prove useful in designing field planting strategies that seek to optimize triploid watermelon production.

232 Inverse Day/Night Temperature Influences Yield and Canopy Height of Hydroponically Grown Sweetpotato

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Growth chamber studies were conducted to determine if inverse day/night temperature could control canopy height of sweetpotato without adversely affecting storage root yield. Four 15-cm-long vine cuttings of TU-82-155 sweetpotato were grown in rectangular nutrient film technique hydroponic troughs for 120 days. Two troughs were placed into each of six reach-in growth chambers and subjected to 24/18, 26/20, 28/22, 18/24, 20/26, and 22/28 °C, respectively. Growth chamber conditions included a 12/12-h photoperiod, 70% RH, and photosynthetic photon flux of 1000 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ at canopy level. Total and edible storage root yields were reduced by 50% among plants grown under cool days/warm nights regimes. Harvest index was similar among treatments except for the low value obtained at 22/28 °C. Canopy height was positively correlated with the change in temperature, and for every 2 °C decrease there was a 3.1 centimeter decrease in canopy height. Inverse day/night temperature effectively controlled canopy height but at the expense of storage root production.

233 Alteration of Flower Development and Fruit Growth in Summer Squash

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Many summer squash hybrids initiate flowering by first producing one or more pistillate flowers before the development of any staminate flowers. These first pistillate flowers have no pollen source unless an earlier squash planting is nearby. The objectives of this study were to measure the loss in yield incurred by the absence of pollination and to determine if sex expression in squash could be altered by use of gibberellic acid (GA). 'Cougar' summer squash was planted in 12 isolated plots on 13 May; four plots had adjacent rows planted on 3 May to provide pollen for the earliest developing pistillate flowers in those plots. On 28 May, 0.146 L·ha⁻¹ of GA (ProGibb 4[®]) was applied to an adjacent row in four of the plots planted on 13 May. The four control plots received no treatment. At anthesis, pistillate and staminate flowers were counted daily for 10 days. The first six pistillate flowers that bloomed in each plot were identified and measured (length and diameter) on the day of anthesis, and at 4 and 7 days after anthesis. Fruit were harvested five times at 2-day intervals and data are reported on fruit ≤ 5.7 cm in diameter. GA had no effect on squash flowering habit. At 4 and 7 days after

anthesis, fruit were smaller in plots where no pollen source was available. Early yields were higher for the first two harvests in plots where pollinators were present. A small, early planting of squash should be made to provide staminate flowers for normal growth and development of early fruit on the main summer squash crop.

234 Foraging Pattern Comparisons between Two Commercial Pollinators on Field-grown Watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai]

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The need for alternative [non-honey bee (*Apis mellifera* L.)] pollinators continues to increase as the number of problems facing the American beekeeping industry increase. One readily available alternative pollinator source is commercially produced bumblebee (*Bombus* spp.) colonies. From 1997 to 1999, three studies were conducted to compare the pollination efficacy of bumblebee and honeybee pollinators on field-grown watermelon. The experiments documented 1) bee activity periods (the onset and termination of foraging behavior in association with watermelon anthesis and duration), 2) floral visitation rates (number of flowers visited per unit time by individual foragers), and 3) stigmatic pollen deposition (number of pollen grains deposited on stigmata during single bee visits to pistillate watermelon flowers over the course of anthesis). Bumblebees outperformed honeybees in all three comparative experiments. *Bombus* foragers initiated foraging activity 30 to 60 min before the appearance of the first honey bee foragers. Both bee types continued to forage throughout anthesis once appearing in the field. Individual bumblebees consistently visited two or more times the number of flowers per min than did honeybees ($P < 0.0001$) throughout the day excluding the initial 30 to 60 min when honeybees did not forage. The number of pollen grains deposited in an initial visit to stigmata by *Bombus* foragers was consistently greater than for honeybees ($P < 0.001$). For both bee types, pollen deposition was influenced by time of day, peaking at 0900 HR and then declining until 1200 HR, when the flowers closed. Both foraging rates and pollen deposition favored bumblebees over honeybees regardless of time of day.

235 Evaluation of Southern Pea Cultivars and Breeding Lines for Earliness, Maturity, and Yield in Multiple-year Trials in South Texas

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Southern peas for the processing market are an important crop for producers in South Texas, but little testing of new varieties or breeding lines has been carried out. Grower field trials during three different years and an on station trial provided an opportunity to evaluate >30 different pea cultivars or breeding lines. Cultivars and breeding lines were evaluated for earliness, maturity, yield, and performance in high-pH soils. Yields varied significantly each season, with Arkansas Blackeye # 1 providing consistently high yields in the three grower trials. Both Arkansas 87-435-68 and Texas Pinkeye produced significantly higher yields in the high soil pH trial at Weslaco. Yields for Arkansas 87-435-68 and Texas Pinkeye in the Weslaco trial were 1428 and 1231 lb of dry peas per acre, respectively.

236 Heirloom Tomato Cultivar Evaluation

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The specialty vegetable market is a rapidly expanding niche in the produce industry. One popular sector of this market is focused on heirloom tomatoes. Heirloom varieties, mostly open-pollinated, are often favored for their taste and unique shapes and colors. Older, traditional varieties have been maintained mostly by home gardeners, seed saver organizations, and government germplasm centers, but are becoming increasingly popular with commercial growers, consumers, and seed companies. Special growing techniques and attention to postharvest handling is also necessary with heirloom tomatoes because most do not have an extended shelf life. For growers willing to develop special harvesting and handling techniques, specialty tomatoes offer colors, shapes, and flavors that are an

important part of today's cuisine. Performance of a given cultivar will vary from year to year depending on several factors: planting date, irrigation, disease pressure, staking practices, and climatic conditions during the growing season. Fourteen heirloom tomato cultivars have been researched at Ohio State Univ. (OSU) since 1995. Data collected on yield, fruit characteristics, market outlets, cultural information, special harvesting and handling requirements, and disease pressure for heirloom cultivars will be presented.

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Evaluation of Green Snap Bean Varieties in Northwestern Mexico

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Vegetable production in the Caborca area is about 6500 ha, and the main crops are asparagus, muskmelon, watermelon, and pea. However during 1999, some growers tested green snap beans as a new crop for this area. The objective of this experiment was to evaluate five green snap beans with round podded ('Benchmark', 'Landmark', 'Jade', 'Probe', and 'Prosperity') and two densities (14 and 28 seeds/m) on subsurface drip irrigation system. The sowing was on beds of 2.0 m with two rows separated 60 cm. The date sowing was on 7 Sept. 1999. The first cutting were between 65 and 70 days after sowing in all varieties; in this case 'Benchmark' was the earliest. The cumulative yield were 330, 140, 87, 63, and 20 boxes/ha (30 lb/box), respectively, in four harvests. On the other hand, the high population yielded 14.4% more than the low population. All varieties were damaged by frost that occurred on 22 and 23 Nov. 'Prosperity' was more susceptible to mosaic virus and 'Benchmark' more tolerant. The pod quality distributions were 19.9%, 21.5%, 26.1%, and 21.0% for classes 1, 2, 3, and 4, respectively. We have not seen any important insect pests during this trial.

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Seed Size Effects on Brassica Transplant Production

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The growing of transplants in plug cell trays is the primary method of producing brassica transplants in many countries. Seed quality is an important aspect to achieve success in transplant production. Seed size may affect seed performance, seedling growth and development of brassica transplants. Seeds of cauliflower ('Vitoria de vero') and cabbage ('Unio') from Embrapa Vegetables were used in this study. During seed conditioning, seeds were classified using round screens generating three (>1.5, 1.5–2.0, and 2.0–2.5 mm) and four (>1.5, 1.5–2.0, 2.0–2.5, and < 2.5 mm) seed size categories, for cauliflower and cabbage, respectively. The original seed lot was used as control. Seed weight increased with seed size. Seed germination (laboratory) and seedling emergence (greenhouse) were not affected by seed size. In both species, root and shoot weight, and leaf area, measured 30 days after seeding, in greenhouse conditions, increased with seed size. Also, transplants from larger seed size resulted in a significantly higher root weight, shoot weight, and leaf area relative to the original (control) seeds. The results indicate that, overall, an adequate seed conditioning improve brassica transplant quality.

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Seed Germination and Seedling Characteristics of Cucurbits as Affected by Dry Heat Treatment and Subsequent Handling

Hae-Jeen Bang, Soo-Jung Hwang, Hyun-Sook Ham, and Jung-Myung Lee*; Dept. of Horticulture, Kyung Hee Univ., Yongin 449-701, Republic of Korea

Dry heat treatment has been commonly used to inactivate some seed-borne pathogens in vegetable seeds. Virtually all the gourd seeds for watermelon rootstock are being treated with dry heat to inactivate cucumber green mottle mosaic virus (CGMMV, a strain of tobamovirus) and *Fusarium*. Seeds of five gourd and one squash cultivars were treated with dry heat (35 °C for 24 h + 50 °C for 24 h + 75 °C for 72 h) and, immediately after the dry heat treatment, the seeds (moisture content of 1% or lower) were allowed to absorb atmospheric moisture in a moisture saturated chamber until the seed moisture contents reached 2% to 8%. After the equilibrium obtained, the seeds were sealed in air-tight bags and stored for 1 day or 30 days at 20 °C. The seeds were then sown in cell trays and the emergence and seedling characteristics were evaluated. Dry heat treatment caused significant delay in emergence in all tested cultivars, but had little or no influence on the final emergence rate. Moderate to severe injury was observed in seedlings

grown from dry heat-treated seeds in three out of six cultivars tested. However, little or no dry heat phytotoxicity was observed in other cultivars, thus suggesting the marked differences in cultivar susceptibility to dry heat treatment. Rapid humidification before sealing also appeared to reduce the early emergence rate in some cultivars, but had no effect on the final emergence rate in most cultivars. Storage of dry heat-treated seeds in sealed bags for 30 days before sowing was highly effective in minimizing the phytotoxicity symptoms in seedlings as compared to the seedlings grown from the seeds sown immediately after the dry heat treatment. This suggests that the reestablishment of metabolic process required for normal seed germination requires a long period after the dry heat treatment. Other characteristics associated with DH treatment will also be presented.

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Sudden Tree Decline and Death of Pecan

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This study reports on sudden death (or decline) of mature and apparently healthy pecan trees [*Carya illinoensis* (Wangenh.) K. Koch]. Observations suggest that death and damage is due to winter cold injury (although the season's low was only –5 °C). The severity of this cold injury-like form of sudden death is closely associated with nut crop load (i.e., grams of kernels per square centimeter of trunk cross-sectional area) and premature defoliation. Both dead and declining trees not only produced relatively heavy crops, but also exhibited substantial premature pest-induced defoliation the previous autumn. The near absence of sugars and starch in roots and shoots of dead or declining trees at budbreak and the relatively high levels in healthy trees indicates that diminished assimilate reserves during the dormant season were the key factor causing death or decline. The diminished assimilate reserves prevented the accumulation of assimilate reserves necessary for maintaining live roots throughout the dormancy and prevented proper cold acclimation of shoot tissues. Distinct symptoms of sudden tree death or decline compared to typical cold damage are: a) a distinct top-to-bottom gradation of tree damage, with an increased proportion of dead shoots and shoots supporting abnormally small foliage being near the base of the canopy; b) desiccated and tan appearance of inner bark and phloem of the main trunk rather than brown coloration so typical of classical cold injury; c) death of roots by time of budbreak; and d) absence of resprouting from the trunk or root collar. These observations indicate that pecan trees can suddenly die due to being overly stressed for assimilates and that economic losses previously attributed to injury by severe winter cold sometimes may be due to depleted assimilate reserves during the dormant season as a result of overcropping and premature defoliation.

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Effect of Scion–Rootstock Combinations on Premature Fruit Drop in Mango

D. Predner and A. Cedeno-Maldonado*; Department of Horticulture, University of Puerto Rico, Mayaguez, PR 00680

Studies were conducted to determine the effect of scion–rootstock combinations on premature fruit drop. Ten-year-old trees of the varieties Parvin and Tommy Atkins grafted on Eldon, Malda, Colombo Kidney, Julie, and Cuban were used. The number of prematurely dropped fruits was counted weekly for 8 consecutive weeks after flowering. A smaller fruit drop index was observed when 'Parvin' was grafted on Malda, Julie, and Cuban than when grafted on Colombo Kidney. There was no significant difference in fruit drop index between Eldon and Colombo Kidney. Fruit drop index was greater in 'Parvin' than in 'Tommy Atkins'.

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Fruit Quality Parameters of Various Apple Scion/Rootstock Combinations

Usman Siswanto* and Frank B. Matta: Department of Plant and Soil Sciences Mississippi State University, PO Box 9555, 117 Dorman Hall, Mississippi State MS 39762

A study of spur-type apple scion cultivars on semi-dwarf and dwarf apple rootstocks was conducted to evaluate and identify suitable scion/stock combination for Mississippi. Fruit weight varied among scion/stock combinations. 'Royal Gala' on MM111 and MM106 and 'Ultra Gold' on MM106 yielded the heaviest fruit. 'Jon-A-Red' on Mark produced the lightest fruit. Fruit length diameter ratio (L/D) was the highest for 'Blushing Golden' on M7A and MM111, and 'Ultra Gold' on MM111. The L/D ratio of 'Royal Gala' was not affected by rootstock. Scion

cultivars on M7A and M26 tended to have more red fruit than on the remaining rootstocks. 'Ultra Gold' on M26 and 'Braeburn' on Mark and MM111 had the firmest fruit. Overall, trees on M7A and Mark rootstock tended to produce firm fruit. Juice pH was significantly affected by scion-stock combination. In general, 'Royal Gala', regardless of rootstock, had the highest juice pH, whereas 'Ultra Mac' and 'Jon-A-Red' produced the lowest pH. 'Blushing Golden' on MM111 and 'Royal Gala' on M26 had the highest soluble solids concentration (SSC). Soluble solids concentration of scion cultivars on MM106 did not differ.

243 Manipulation of Peach Tree Growth and Development Using Graft-transmissible Agents

Phillip G. Gibson^{*1}, Gregory L. Reighard¹, Simon W. Scott², and David R. Ouellette¹; Departments of ¹Horticulture and ²Plant Pathology, Clemson University, Clemson, SC 29634

Delaying bloom to reduce spring frost risk and reducing labor costs by increasing orchard efficiency are important goals of peach producers. At the Musser Fruit Research Center near Clemson, S.C., 'Coronet' peach trees were inoculated with Peach Latent Mosaic Viroid (PLMVd) to induce bloom delay and reduce shoot vigor. Trees were grown in a high-density, Y-trained orchard system to determine the potential benefit of reduced shoot vigor on labor efficiency in summer pruning operations. In Aug. 1997, 'Ta Tao 5' buds were grafted onto the scaffolds of 2-year-old 'Coronet' peach trees to transmit PLMVd. Transmission was confirmed by dot-blot on N+ nylon membranes using cRNA probes. Bloom was not delayed in the following year, Spring 1998, but bloom was delayed 7 days in Spring 1999. Yields were unaffected in 1998, but the total fruit weight produced on PLMVd-treated trees was significantly less in the 1999 harvest. Individual fruit weight, firmness, and color were improved on the treated trees. Shoot vigor was reduced on the PLMVd treated trees in the summers of 1998 and 1999, resulting in a significant reduction in pruning time and pruning weights. Light penetration was significantly increased in the treated trees when compared to the untreated controls in the summers of 1998 and 1999. Fruiting shoot length and the number of fruit per shoot was unaffected by the PLMVd presence. The trunk cross-sectional area was significantly less on the treated trees when compared to the untreated controls after each year of growth. Autumn defoliation occurred earlier on the treated trees in Fall 1998 and Fall 1999. The manipulation of peach tree growth and development was accomplished using graft transmissible agents as PLMVd induced several beneficial growth and developmental modifications in established peach trees.

244 Antioxidant Activity of Opuntia Cactus Pears

J.O. Kuit^{*}; Horticultural Crops Research Lab., Texas A&M University-Kingsville, TX 78363

Flavonoid content and antioxidant activity in peel and pulp samples of four different cactus pear fruit varieties were investigated. Major cactus fruit flavonoids were quercetin, kaempferol, and isorhamnetin. Greater amount of quercetin was found in the pulp compared with the peel samples in all varieties examined. Both kaempferol and isorhamnetin were found in at least three of the varieties (*Opuntia ficus-indica*, *O. lindheimeri*, *O. streptacantha*) exclusively in the peel samples. Generally, pulp tissue samples of all the cactus fruit varieties contained greater ascorbic acid, glutathione, alpha-tocopherol and beta-carotene and antioxidant activities than the peel tissue samples. Total flavonoids correlated well with antioxidant activity ($r^2 = 0.89$). Ascorbic acid had the highest antioxidant activity, followed by glutathione, beta-carotene, and alpha-tocopherol on equimolar basis.

245 Apples of Northeastern America

S. Khanizadeh, Y. Groleau, J. Cousineau, B. Thériault, J.R. DeEll^{*}, C. Beldica, and H. Boddington; Agriculture and Agri-Food Canada, Horticultural Research and Development Centre, 430 Gouin Blvd., St-Jean-sur-Richelieu, Québec, Canada J3B 3E6

One of the major problems affecting apple trees in Eastern Canada is low temperature injury during the winter and spring. Although there have been many studies on the cold hardiness of apple trees, no survey has been done on winter injury in Québec orchards. A survey was conducted in 1995/1996 to identify factors responsible for apple tree mortality during the winter of 1993/1994 in Québec. Three-hundred-thirty (330) apple orchards were visited and information on more than 50 characteristics were evaluated via a questionnaire; including

hardiness, end use, shelf-life, etc. A full report is available at <http://www.pgris.com>. A large diversity of cultivars and rootstocks was observed in the Québec orchards, and thus a database was created containing information for all cultivars evaluated and the collected agronomic characteristics. Some of the more important information, such as hardiness, end use, shelf-life, scab resistance, etc., along with 265 apple images, were put together as a poster. A copy of this poster is available from <http://www.pgris.com>.

246 Least Squares Means Comparisons for Interaction Means in a Two-factor Study in Apple Rootstock Trials

Michele Marini^{*1}, Klaus Hinkelmann¹, and Richard Marini²; Departments of ¹Statistics and ²Horticulture, Virginia Tech, Blacksburg, VA 24061

Trunk cross-sectional area data for an NC-140 apple rootstock trial were collected in 1998. There were 18 rootstocks and 20 states, and these factors were arranged in a factorial structure; the interaction term (variety x state) was statistically significant ($P < 0.05$). There were 10 trees of each rootstock planted in each state, but some trees died and this created unequal numbers of observations. Historically these data would have been analyzed using PROC GLM in SAS, correctly identifying the interaction significance, and then analyzing differences for states within a rootstock, and differences for rootstocks within a state. This analysis would not take advantage of all the replication available in the study. To more appropriately utilize the available replication, and to account for the unbalanced number of observations, a macro program was written in SAS. The slice option in PROC MIXED generates individual significance levels for the rootstock factor within a state, but does not make comparisons between rootstocks within a state. The SAS macro was written to use the individual error terms and least squares means generated from PROC MIXED to make each individual Tukey's multiple comparison between rootstocks within a state. The justification for this analytical approach, the SAS macro, and the results of the analysis will be presented.

247 Early Growth and Development of Container-grown Pawpaw Seedlings in Various Potting Media and Nutrient Regimes

Kirk W. Pomper^{*}, Snake C. Jones, and Eddie B. Reed; Atwood Research Facility, Kentucky State University, Frankfort, KY 40601-2335

The pawpaw [*Asimina triloba* (L.) Dunal] is a native American tree fruit with potential in edible landscapes and as a new fruit crop. A split-plot experiment (main plot: fertilizer level and subplot potting medium) was conducted in the greenhouse to identify the best growing medium for production of pawpaw seedlings. Seeds were sown in rootainers containing one of the following media: 1) Promix (control); 2) 6 pine bark:1 mason sand (v/v); 3) 1 mason sand:1 sphagnum peat; and 4) 4 pine bark:1 mason sand:1 sphagnum peat. When seedlings had at least two to three leaves, weekly fertigation of seedlings began, using 0, 250, or 500 ppm Peters 20N-20P-20K. Germination rate at 10 weeks was similar in all media, at about 80%. The plants were destructively harvested 10 weeks after imposition of fertigation treatments. Both potting media and fertigation influenced leaf number and height; however, there was a significant interaction between these main effects. Leaf number and height for plants in medium 3 were similar to those of the control (medium 1), at about 11 leaves and 18-cm plant height, respectively, at 500 ppm fertigation. Plants in media 2 and 4 were about half as tall and had about half as many leaves as control medium plants at 500 ppm fertigation. Plant leaf area and biomass data will be discussed.

248 Influence of Early Rowcover Removal and Supported Rowcovers on Yield, Earliness, and Fruit Size of Strawberries Grown under Plasticulture

Peter Nitzsche^{*1} and Joseph Fiola²; ¹Rutgers Cooperative Extension of Morris County, Morristown, NJ 07963; ²Rutgers Cooperative Extension, Cream Ridge, NJ 08514

Growers in Northern New Jersey are slowly adopting strawberry plasticulture as an improved production system. One advantage of the system is early fruit production. Early fruit usually brings high prices in the marketplace. With early production, however, there is an increased risk of a late frost damaging flowers and fruit. Removing floating rowcover winter protection earlier than flowering may cause strawberries to bloom later, reducing the risk of frost damage. Supporting the rowcovers above the crop with wire hoops may also provide better winter protection and improve fruit production. In 2 years of field trials, removing

floating rowcovers 2 weeks before anticipated bloom reduced early yield and delayed the first harvest by 2 to 3 days. Total marketable yield and average fruit weight were not significantly influenced by early removal. Plants with rowcovers supported with wire hoops did not produce significantly greater total yields or average fruit weights than plants protected by unsupported rowcovers. The wire hoops caused damage to the rowcovers, which may make their use in commercial production impractical.

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Cropping Highbush Blueberry in Coal Ash-Compost Mixtures

Brent L. Black* and Richard H. Zimmerman; U.S. Department of Agriculture, Agricultural Research Service, Fruit Laboratory, Beltsville, MD 20705

Highbush blueberry plants require low-pH, well-drained sandy soils. To increase the range of sites available for highbush blueberry production, by-products were tested as constituents in soilless media and as soil amendments. By-products, including coal ash, municipal biosolid compost, leaf compost, and acid peat, were combined in different proportions and compared to Berryland sand (alone) and Manor clay loam (alone and compost-amended) for a total of 10 media treatments. The pH of all treatment media was adjusted to 4.5 with sulfur. One-year-old tissue-cultured plants of 'Bluecrop' and 'Sierra' were planted in 15-L pots containing the pH-adjusted treatment media in 1997, producing their first substantial crop in 1999. For the 1999 crop, ripe fruit was harvested at weekly intervals over 5 weeks. ANOVA for yield indicated a significant cultivar x media interaction. 'Bluecrop' appeared more sensitive to media treatment as yields on Manor clay loam were 80% less than on Berryland sand. Yields of 'Bluecrop' on coal ash-compost mixes were similar to that of Berryland sand, and 1:1 coal ash:compost mixes produced significantly higher yields than did the 3:1 mixes. Yield of 'Sierra' on Manor clay loam was 41% less than on Berryland sand, and plants growing on soilless mixes yielded 17% to 58% more than those on Berryland sand. 'Bluecrop' fruit size was greatest for Berryland sand, but did not differ significantly among coal ash-compost mixes. For all media treatments, 'Sierra' fruit size was inversely correlated with yield. Fruit from 'Bluecrop' plants on coal ash-compost mixes ripened slightly earlier than on Berryland sand, but ripening date of 'Sierra' did not vary significantly with soil treatment. The potential for employing these by-product mixes in small-scale commercial blueberry production will be discussed.

94 POSTER SESSION 12 (Abstr. 250–277)

Crop Production

Tuesday, 25 July, 1:00–2:00 p.m.

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Ornamental Cabbage and Kale Growth Response to Plant Growth Regulators

James L. Gibson* and Brian E. Whipker; North Carolina State University, Dept. of Horticultural Science, Campus Box 7609, Raleigh, NC 27695-7609

Ornamental cabbage and kale (*Brassica oleracea* var. *acephala* L.) plants of cultivars 'Osaka White' and 'Nagoya Red' were treated with paclobutrazol and uniconazole as foliar sprays or soil drenches. These treatments were compared to the industry standard of daminozide foliar sprays. Ten plant growth regulator (PGR) drench treatments (in mg a.i./pot) were applied 22 days after potting: paclobutrazol at 1 to 16 and uniconazole at 0.125 to 2. Thirteen PGR foliar sprays (in mg/L) were also applied: paclobutrazol at 5 to 80, uniconazole at 2 to 32, daminozide at 2500, 2500 (twice, with the second application occurring 14 days later), or 5000, and an untreated control. Applying drenches of paclobutrazol at 4 mg or uniconazole at 0.5 mg controlled height by 16 to 25%, but at the cost of \$0.11 per pot would not be economically feasible for growers to use. Paclobutrazol foliar sprays at concentrations of up to 80 mg/L were ineffective in controlling plant height and diameter of either 'Osaka White' or 'Nagoya Red'. Uniconazole foliar sprays between 2 and 8 mg/L were effective in controlling height (by 19%) and diameter (by 15%) as daminozide foliar sprays of 2500 mg/L, sprayed twice, with a cost to the grower of \$0.02 per pot.

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Humic Acid Substrate Treatments and Foliar Spray Application Effects on Root Growth and Development of Seedlings

Gang Li* and Michael R. Evans; Department of Horticulture, Iowa State University, Ames, IA 50011

Seedlings of *Cucumis sativus* (cucumber), *Tagetes patula* (marigold), *Viola tricolor* (pansy), *Pelargonium x hortorum* (geranium), and *Impatiens wallerana* (impatiens) were germinated on towels soaked with either deionized water, nutrient control solutions, or humic acid solutions. Root fresh weight and root dry weights were higher for all seedlings germinated on towels soaked with humic acid as compared to seedlings germinated on towels soaked with deionized water or nutrient control solutions. Lateral root number and total lateral root length were higher for cucumber, marigold, pansy, and geranium seedlings germinated on towels soaked with humic acid than those germinated on towels soaked with deionized water or nutrient control solutions. Root fresh and dry weights were higher for impatiens, *Begonia semperflorens* (begonia), marigold, and geranium seedlings germinated in a sphagnum peat : vermiculite (80:20, %v/v) substrate drenched with humic acid as compared to seedlings germinated in substrate drenched with deionized water or nutrient control solutions. Foliar sprays of humic acid also resulted in increased root fresh and dry weights while foliar application of nutrient control solutions either had no effect or reduced root fresh and dry weights.

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Effect of Harvesting Technique and Genotype on Cut Flower Production of *Alstroemeria*

Eduardo Olate* and Mark Bridgen; Dept. of Plant Science, University of Connecticut, Storrs, CT 06269

The effect of harvesting procedures on the production of cut flowers of *Alstroemeria* was determined by growing six different cultivars from three different response groups with three different harvesting techniques. The orchid-type cultivars tested were 'Parigo Red' and 'Parigo Pink', the butterfly-type cultivars were 'Freedom^P', 'Patriot^P', and 'Patricia Lynn', and the hybrid-type cultivar was 'Sweet Laura^P'. The different harvesting treatments were "cutting," "pull," and "no harvesting" (control). Cultivars and treatments were evaluated for date of harvest, number of florets per flowering stem, stem length and number of flowering stems produced per plant. The harvest period covered week 14 to week 34 of 1999. The number of florets produced per inflorescence was not affected by any harvesting treatments. The average length of the flowering stems with butterfly-type and hybrid-type cultivars of *Alstroemeria* decreased over the period of harvest. These two types of cultivars did not differ from each other as a result of the harvesting technique, but did differ from the control plants that were not harvested. The stems from control plants of the butterfly-type and hybrid-type cultivars were longer than those of the harvested plants. The orchid-type cultivars did not exhibit this "short stem effect" as the other two types of cultivars. In both orchid-type cultivars ('Parigo Red' and 'Parigo Pink') and in the hybrid-type cultivar ('Sweet Laura^P') the total number of flowering stems that were produced was greater with the "cutting" technique than with the "pulling" technique of harvest. In the case of butterfly-type cultivars, there was no difference of the number of flowering stems produced between the two harvesting systems, but they differed from the control plants.

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Influence of the Timing of Propagation and Cold Storage on the Growth and Development of *Alstroemeria* Pot Plants

Eduardo Olate*, Doris Ly, George Elliott, and Mark Bridgen; Dept. of Plant Science, Univ. of Connecticut, Storrs, CT 06269

Two butterfly-type cultivars of *Alstroemeria* were used to evaluate the effect of different dates of propagation and cold storage techniques on the growth and flowering of potted plants. The cultivars used were 'Patricia Lynn' and FL-101. Plants were propagated during four different dates of 1997 (weeks 39, 41, 43, and 47) in large nursery pots (3.8 L) or in small nursery pots (1.4 L). Following division, all plants were grown for 4 weeks. After this period of establishment, plants in the large nursery pots were transferred directly to the final growing greenhouse (16 °C nights) and plants in the small pots were refrigerated at 4 °C for 8, 6, 4, or 0 weeks with either complete light or complete dark conditions. Once the cold treatment was accomplished, all plants were transferred on the same date to large nursery pots for finishing with those plants that had been initially propagated in large pots. All plants were cut back on week 3 of 1998. Plants were evaluated for date of harvest, visual evaluation, fresh aerial weight, number and length of flow-

ering stems, and number of florets per flowering stem. Refrigerated treatments delayed the time of flowering when compared to plants that were grown with no refrigeration. Fresh weight and stem length values of plants that were not refrigerated were less than or equal to those of plants that were refrigerated, with the exception of plants that were propagated on week 47. In addition, the number of flowering stems that were produced from plants that were refrigerated was either greater than or the same as plants that were not refrigerated. The presence or absence of light during refrigeration had no effect on subsequent plant growth and development. There were no differences observed among treatments for visual evaluation and number of florets produced per inflorescence. This research demonstrated that potted *Alstroemeria* plants can be propagated early and stored under cold conditions without these procedures affecting final plant performance, but the process will affect the scheduling of the crop.

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Stem Extension and Subsequent Flowering of Plugs Grown Under A Far-red-deficient Film

Erik S. Runkle* and Royal D. Heins; Department of Horticulture, Michigan State University, East Lansing, MI 48824-1325 USA

Environments with a low red (R, 600 to 700 nm) to far-red (FR, 700 to 800 nm) ratio (e.g., with high plant density) promote stem elongation, and a high R : FR suppresses it. While FR light promotes stem extension, it is also required for rapid, uniform flowering of many long-day plants. We investigated how a new FR filter [creating a FR-deficient (FRd) environment] influenced plug growth and subsequent flowering of pansy (*Viola xwittrockiana* 'Crystal Bowl Yellow'), petunia (*Petunia xhybrida* 'Carpet Pink'), impatiens (*Impatiens wallerana* 'Accent Rose'), snapdragon (*Antirrhinum majus* 'Liberty Scarlet'), and tomato (*Solanum lycopersicon* 'Beefmaster'). One-week-old seedlings were placed under three filter treatments with 16-h photoperiods: the FRd filter, a neutral-density filter (N) that transmitted a similar PPF, and transferring plugs from the N to the FRd filter when leaves of each species began to touch (7 to 11 days later). The predicted phytochrome photoequilibria under the FRd and N filters was 0.80 and 0.72, respectively. After 25 to 35 days at 20 °C, node number and stem (or petiole for pansy) length were collected. Twenty plants of each species and filter treatment were then transferred to 4-inch pots and grown under natural photoperiods (14 to 15 h) at 20 °C until flowering. Compared to plants continually under the N filter, stem length under the FRd filter was significantly reduced in impatiens (by 11%), pansy (by 18%), petunia (by 34%), snapdragon (by 5%), and tomato (by 24%). Flowering of plants from plugs under the FRd filter was delayed by 2 to 3 days for snapdragon, petunia, and pansy. Filter treatment of plugs had no significant effect on flower number or plant height at flower.

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Biomass and Phenolic Content of *Echinacea* Species Grown in Kentucky

Jenny Heringer Vires*, Robert Geneve, and Robert Anderson; University of Kentucky, Department of Horticulture, Lexington, KY 40546

Purple coneflower, *Echinacea* sp. (Asteraceae), is a herbaceous perennial native to North America. Within the past decade, extensive research has been conducted to confirm *echinacea*'s immunostimulatory, antiviral, and antibacterial benefits to humans. *E. angustifolia*, *E. purpurea*, and *E. pallida* are the primary species grown and studied for the herbal industry. However, there are other species and cultivars that may produce higher yields in biomass and chemical quality. The objective for this study is to evaluate the differences in biomass and phenolic content of five cultivars of *E. purpurea* and five species of *Echinacea* under Kentucky growing conditions. Differences in biomass (dry weight) of *Echinacea* species and cultivars harvested after the first year of growth was determined. There was a significant difference in total dry weight between *E. purpurea* cultivars. *E. purpurea* 'Bright Star' and 'Clío' produced significantly greater total dry weight compared to all other cultivars. There was no significant difference in root or flower biomass between cultivars. Biomass production differed between *Echinacea* species for root, vegetative, and flower parts. The total biomass of *E. purpurea* and *E. tennesseensis* was significantly higher compared to other species. *E. pallida* and *E. paradoxa* were not significantly different from *E. purpurea* in root biomass, even though both species produced less above-ground growth. *E. tennesseensis* produced 45% to 105% more flowers compared to other species. Differences in phenolic content between species and cultivars will also be presented.

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Effect of Field Applications of Nonselective Postemergence Herbicides on Tulip, Narcissus, and Bulbous Iris

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Tulip, narcissus, and bulbous iris are grown on about 1600 acres annually in western Washington. These bulb crops are poor competitors with winter annual weeds that continually germinate from September through July in the mild maritime climate of this region. Because they do not adequately control emerged weeds but can injure bulb crop foliage, herbicides are applied in the fall. Unfortunately, fall-applied herbicides lack the soil persistence necessary for season-long weed control. If nonselective herbicides could safely be applied after emergence of bulb foliage, emerged weeds would be killed and the application of residual herbicides delayed until spring, thus lengthening the period of weed control through bulb harvest. Glyphosate was tested for selectivity at three postemergence timings (early, middle, and late) on four cultivars each of tulip and iris and three narcissus cultivars. Middle and late glyphosate treatments caused severe injury to tulip foliage and flowers and reduced bulb count and weight, but early glyphosate did not significantly injure most varieties. Narcissus and iris were more tolerant to glyphosate than tulip, but these species also were most tolerant when glyphosate was applied early. In a separate study on iris, carfentrazone, paraquat, and glufosinate were applied postemergence at the same three timings. Glufosinate initially caused moderate injury to foliage (about 20%), but plants quickly recovered. Injury from carfentrazone and paraquat was much more severe (more than 50%), although plant recovery from carfentrazone damage was greater than from paraquat. Bulb yield was not adversely affected by either glufosinate or carfentrazone if applied early. Paraquat at all timings significantly reduced total bulb count and weight.

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Characterization of the Physico-chemical Properties of and Plant Response to Ecologically Sound Organic Substrates in Relation to Rockwool

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Characterization of physico-chemical properties of ecologically sound unprocessed coconut (*Cocos nucifera* L.) coir and carbonated rice husk in relation to rockwool were investigated to examine the crop performance along with productivity of tomatoes (*Lycopersicon esculentum* Mill.). In all substrates, the water-filled pore space and water-holding capacity were larger and air-filled pore space was smaller. Bulk densities, water-holding capacity, and water-filled, air-filled, and total pore spaces were lower in carbonated rice husk than coconut coir and rockwool. These values in coconut coir and carbonated rice husk were increased by use. Most of the physical properties, EC, pH, and inorganic elements, of these natural organic substrates were within appropriate levels as growing media. There were little differences in plant height, stem diameter, percent fruit set, harvest index, ascorbic acid, total soluble solid, fruit pH, and leaf chlorophyll ratio. But, number of nodes, internode length, leaf number and area, days to first anthesis, flower number, and fruit number and weight differed significantly among treatments. There was smaller fluctuation in absolute growth rate, relative growth rate, net assimilate rate, and leaf area ratio among the treatments. It appeared that carbonated rice husk and the coconut coir gave better crop performance than rockwool under moderate high temperatures (30 and 35 °C compared to 25 °C). Furthermore, crop productivity from the organic substrate coconut coir and carbonated rice husk gave more profit than that of rockwool. Thus, carbonated rice husk and coconut coir substrates can be used successfully as a bag culture media amendment for producing vegetables, especially in tropical and subtropical areas.

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Organic Media Alternatives to Peat for Container-grown Tropical Perennial Production

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Peat is used extensively in the nursery industry as a primary component in commercial "soilless" potting media. The increased use of peat as an organic amendment with superior water-holding capacity is challenged by economic and environmental pressures. Developing inexpensive and nutrient-rich organic media alternatives can potentially reduce fertilization rates, irrigation rates, and ulti-

mately, nursery costs. In addition, controversy over the effects of peat mining has inspired a national search for peat substitutes. With our burgeoning population, it is logical to screen waste products as potential alternatives to peat. Growth of *Pachystachys lutea* Nees. (Golden Shrimp Plant) transplants was evaluated in media containing 0%, 25%, 50%, 75%, or 100% compost derived from biosolids and yard trimmings. Compost was amended with a commercial peat- or coir-based media. As compost composition in the peat or coir-based media increased from 0% to 100%, carbon/nitrogen (C/N) ratios decreased, and media stability, N mobilization, pH, and electrical conductivity (EC) increased. Bulk density, particle density, air-filled porosity, container capacity, and total porosity increased as more compost was added to either peat- or coir-based media. Plants grown in media with high volumes of compost (75 or 100%) had reduced leaf area and reduced shoot and root DW than the controls (no compost). Regardless of percentage of compost composition in either peat or coir-based media, all plants were considered marketable after 8 weeks.

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Effect of Photoperiod on Growth and Flowering of Ornamental Ginger Species

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Gingers are tropical perennials from the Zingiberaceae family with attractive long-lived flowers that can be grown as potted plants in subtropical and temperate zones under protected conditions. Development of production practices for this new flowering pot crop is essential for optimum plant growth. The effect of photoperiod on growth and flowering was evaluated on *Curcuma gracillima*, *C. cordata*, *C. alismatifolia*, *C. petiolata* 'Emperor', *Curcuma* 'Chang Mai dwarf', *Siphonichilus decora*, and *S. kirkii*. Plants were grown under daylengths of 8, 12, 16, and 20 h. Plant height, number of new leaves, number of shoots, and leaf area were larger for plants growing under an extended daylength (16- and 20-h photoperiod) than for plants under 8 and 12 h. Plants grown under an 8-h daylength approached dormancy sooner than those growing under 12, 16, or 20 h of light, and no flowering occurred.

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Temperature Change during Development Affects Flowering in *Cyclamen persicum*

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Cyclamen persicum ('Miracle Deep Salmon') was grown at 16 or 20 °C starting at transplant (70 d from seeding). Plants were maintained at the initial temperature of 16 or 20 °C for 3, 6, 9 weeks, or until flowering. Plant development was faster at 20 than 16 °C. Average time at 20 °C was 42 d to color appearance in the flower buds and 68 d to first open flower. At 16 °C, the average time was 58 d to flower bud color and 84 d for first open flower. Plants at 3 weeks of 16 °C flowered at a similar time as plants grown at 20 °C for 9 weeks or throughout. Three initial weeks at 20 °C resulted in similar time to flower as 16 °C throughout although flower color was recorded 9 d earlier for the plants initially at 20 °C. Time between flower bud color and open flowers averaged 26 d at both 16 and 20 °C. Significantly slower development from flower bud color to open flower was recorded with 3 or 6 initial weeks at 20 °C followed by 16 °C.

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The Response to Photoperiod Varies in Closely Related Cultivars of Dwarf Carnation

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Dwarf carnation ('Monarch Yellow' and 'Monarch Purple') was germinated and grown at 20 °C for 3 weeks. Following transplant (21 d from seeding), seedlings were grown at 16 °C and either 9 or 16 hr daylength. Irradiance was adjusted to 10 mol/m² per day. Growth and development in response to photoperiod was significantly different for the two cultivars in the 'Monarch' series. Flowering at long days was faster with 118 d from seeding for 'Monarch Yellow' and 128 d for 'Monarch Purple'. Under short days, flowering was observed 128 d from seeding in 'Monarch Yellow' and 144 d for 'Monarch Purple'. Ten days with short photoperiod initiated at transplant followed by long days resulted in more branching without significantly delayed development for 'Monarch Yellow'. No effect on branching or rate of development was observed in 'Monarch Purple' with 10 initial short days compared to long days throughout.

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Standard Time Domain Reflectometry Curves for Cyclic Irrigation Management in Container Production

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The physical properties of soilless substrates used in the nursery industry vary widely throughout the US, and, as such, present problems for accurate irrigation water management. Water management in soilless substrates is also a key factor in reducing the loss of soluble nitrogen and phosphorus from the root volume. Automated irrigation control that maintains the substrate water content above levels of plant water stress, yet below the maximum water holding capacity of the substrate will serve several positive roles: water and nutrients will be conserved, and losses from run-off minimized. We investigated whether Time Domain Reflectometry (TDR) moisture sensors can be effectively calibrated for a range of horticultural substrates in various container sizes. A series of water desorption curves and TDR wave-traces (n = 10) were simultaneously derived for six soilless substrate source materials (pine bark, hardwood bark, promix, perlite, rockwool and a sieved sand control), using a modified tension table with four column heights (7-, 15-, 20-, and 25-cm equating to rockwool, #1, #3, and #5 pot sizes). Modifying the tension table allowed for the replication of individual columns (n = 10) of each substrate. The volumetric water desorbed at increasing desorption (positive air) pressures from 0 through 100 KPa was collected for each treatment. Repeated measurements with this apparatus allowed us to plot standard TDR curves for each substrate that can be used to accurately schedule cyclic irrigations. Implementing automated cyclic irrigation strategies in container production will allow for better monitoring and control of irrigation applications, and help conserve water and nutrients in the nursery.

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Photoselective Films Influence Flowering of Photoperiodic Species

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Growth chambers constructed from photoselective plastic films were used to investigate the effects of light quality on height manipulation and flowering of photoperiodic plant species. Three types of treatment films were used; control, a far-red light intercepting film (YXE-10) and a red light intercepting film (SXE-4). The red (600–700 nm):far-red (700–800 nm) ratios and phytochrome photoequilibrium estimates for the control, YXE-10 and SXE-4 films were 1.0 and 0.71, 1.5 and 0.77, and 0.71 and 0.67, respectively. The photosynthetic photon flux was adjusted to uniformity among chambers using neutral density filters. Spectral filters did not effect minimum and maximum air temperatures. Experiments were conducted using quantitative long day (*Antirrhinum majus* and *Petunia x hybrida*), quantitative short day (*Zinnia elegans* and *Dendranthema x grandiflorum*) and day-neutral (*Rosa x hybrida*) plant species under natural short-day conditions. Plants produced under the YXE-10 filters were significantly shorter than the control plants, while plants produced under the SXE-4 films had similar or increased height compared to the control plants. However, both height response and flowering times varied with the crop species. Flowering time of *Rosa x hybrida* plants was uniform among all treatments. Flowering of quantitative long-day plants was delayed by at least 10 days under the YXE-10 film and was most responsive to the filtered light. Flowering of quantitative short-day plants was delayed by 2 days under the YXE-10. Days to flower for plants produced under the SXE-4 film were similar to the control plants for all species tested.

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Richards Function Applied to a Daily Additive and Iterative Approach to Model Rose Plant Stem Length Growth

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Height data were collected three times weekly between pinch and flowering to represent 'Royalty' rose (*Rosa hybrida*L.) response to 15 unique treatment combinations of irradiation as photosynthetic photon flux (PPF: 50 to 300 μmol·m⁻²·s⁻¹), day temperature (DT: 12 to 22 °C), and night temperature (NT: 15 to 25 °C) under constant growth chamber conditions. Combinations were determined according to the rotatable central composite design. A previous full quadratic model approach was compared with a revised approach using a nonlinear Richards func-

tion derivative form. This allowed a dynamic change of parameter values for each daily growth iteration by computer. The Richards function assumes nonconstant daily growth rates are proportional to current size; Euler integration enabled additive accumulation of these values. Ratios of the growth constant (k) to the theoretical catabolic constant ($m = v+1$) caused flexible changes in the growth curve, which were compared with the previous quadratic approach.

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Influence of Frozen-in Storage Duration and Forcing Temperature on Flowering of Oriental Hybrid Lilies

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The effect of long-term storage of lily bulbs at $-2\text{ }^{\circ}\text{C}$ and of high temperatures on plant height and floral abnormalities was investigated with Oriental hybrid lilies in 1997–2000. 'Acapulco' and 'Simplon' bulbs were stored frozen at $-2\text{ }^{\circ}\text{C}$ and forced in regular greenhouses with varying temperatures between 12 to 30 $^{\circ}\text{C}$, depending on the season, and also air-conditioned greenhouses where temperatures were maintained year-round at 15.5 to 16 $^{\circ}\text{C}$ or 18 to 18.5 $^{\circ}\text{C}$. Floral development was observed under a scanning electron microscope after $-2\text{ }^{\circ}\text{C}$ treatment. At flowering, stem length with dried and green leaves, number of leaves, and number of normal and abnormal flowers were counted. Although frozen-in storage duration affected plant height, flowering, and the number of abnormal flowers, high temperatures during summer significantly affected the speed of flowering, plant height, and the number of abnormal flowers. High temperature damage can be prevented by growing bulbs at low temperatures immediately after planting the frozen-in stored bulbs. Bulbs can be stored for 12 months to produce quality cut Oriental hybrid lily flowers.

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Response of Winter-injured Peach Trees to Pruning

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When temperatures reach $-26\text{ }^{\circ}\text{C}$ and lower, even for brief periods of time, damage to fruit buds and woody tissue of the peach tree is common. Low temperature injury on peach can lead to bark damage, gummosis, increased incidence of perennial canker, partial or complete crop losses, reduced shoot growth and/or tree death. In Jan. 1994 the Eastern Panhandle of West Virginia and surrounding states experienced three successive nights of temperatures at $-28\text{ }^{\circ}\text{C}$ or lower. Beginning in Apr. 1994, 7-year-old 'Blake/Lovell' peach trees were subjected to four pruning levels (none, light, heavy, and dehorned) each at three times (April, May, and June) in a replicated factorial arrangement. Specific pruning treatments were applied only in 1994; a local commercially recommended level and time of pruning were applied to all trees from 1995 through 1998. Treatments had a significant effect on canopy volume and fruit yields. Trees receiving no pruning or dehorned trees and trees pruned in June had lower yields in 1995 than trees pruned in April or May or trees receiving a light or heavy pruning. These treatments also produced fewer large fruit at harvest. Lower yields and smaller fruit led to reduced dollar returns per hectare in 1995. Yields from 1996 through 1998 were lower for trees that were dehorned pruned in 1994 although there were little or no differences in fruit sizes between treatments. Time and/or level of pruning had effects on the number of cankers and number of large ($>5.1\text{ cm}$) cankers.

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Improving Red Color on Apples with a Reflective Groundcover

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In many years, apples grown in the mid-Atlantic region fail to exhibit a high percentage of the dark red color that buyers and consumers desire. In 1996, we initiated studies to examine the use of a metalized silver low-density polyethylene reflective groundcover (RGC) to improve red color on several apple cultivars under several training systems. A RGC placed in the orchard drive middle of 8-year-old 'Delicious' apple trees trained to a "Y" trellis increased the percent surface red color and resulted in darker, more red-colored apples at harvest. A RGC increased surface red color on 'Empire' apples on a "Y" trellis, but on central leader-trained

semi-dwarf and standard size 'Empire' showed no effects on color. Central leader-trained 'Fuji'/'EMLA.7' apples with a RGC had more red color than untreated fruit at harvest. In 1997, RGC placed under the canopy of 3-year-old 'Fuji' trees trained to a "Y" trellis increased the full sunlight on the underside of the canopy by 28%. Ambient air temperatures within the RGC illuminated canopy averaged 2.1 $^{\circ}\text{C}$ higher than the non-RGC canopy. The level of percent full sunlight was increased within the canopy of well-pruned 32-year-old 'Miller Spur Delicious' apple trees 4- to 8-fold with RGC placed in the row middle or under the canopy in a commercial orchard in 1998. Position of the RGC to the canopy affected fruit red color response differently between the lower and upper part of the canopy. Bins of fruit graded with a commercial color sorter showed no difference in fruit color; however, there was a strong trend toward increased red color where the RGC material was applied.

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Effect of Temperature on Micropropagated Apple Plants as a Way to Overcome Plant Growth Cessation During Acclimatization

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The present work aimed to evaluate the plant growth of the apple rootstock Marubakaido during the acclimatization process, after receiving different treatments of temperatures. Apple shoots were rooted in vitro and transplanted to greenhouse, where they remained for 2 weeks. After this period, the plants were treated under temperature of $4 \pm 1\text{ }^{\circ}\text{C}$ and $10 \pm 1\text{ }^{\circ}\text{C}$, 16-h photoperiod at $5\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ radiation for 0, 360, 720, 1080, and 1440 h. The plants were transferred to the greenhouse where their growth internode length and bud number were evaluated during 2 months. It was verified that there was an increase up to 697% in the height of the plants when they were treated for 1440 h, independently of the temperature. The internode length was also larger when the plants were treated for greater periods. The temperature of $10 \pm 1\text{ }^{\circ}\text{C}$ led to a decrease in the bud number, while at $4 \pm 1\text{ }^{\circ}\text{C}$, significant differences were not observed. These results suggest that the use of higher temperatures ($10 \pm 1\text{ }^{\circ}\text{C}$), can also recover the plant growth during the acclimatization process.

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Evaluation of Low-chilling Requirements of Apricot Selections in Northwestern Mexico

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Apricot production in México is limited; actually, the area devoted to this crop is $\approx 880\text{ ha}$, of which 230 ha are established in Sonora State. The main cultivar used is 'Canino'. The fruit yield ranges from 15-20 $\text{t}\cdot\text{ha}^{-1}$. The present study tested 20 low-chilling (300 to 400 chill hours) requirements of apricot selections; 'Nemaguard' was the rootstock used. On the 4th production year from the 20 apricot selection tested, 7-23, 1-81, and 15-1 yielded 31.8, 20.2, and 15.5 $\text{Ton}\cdot\text{Ha}^{-1}$, respectively; all of these selections showed higher yields than the Canino cultivar ($14.6\text{ t}\cdot\text{ha}^{-1}$). The fruit of these apricot selections ripened by mid-May, exhibiting all the tested selection a similar fruit quality (size, flavor, color, and °Brix). We have not recorded any important insect pests or diseases during this trial.

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Effects of Chemical Thinners on Yield, Fruit Size, and Fruit Quality of 'Honeycrisp' Apple

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Effects of chemical thinners on yield, fruit size, and fruit quality was studied in a commercial orchard in Milton, N.Y., on 6-year-old 'Honeycrisp'/'M.26' trees. The trees were planted at 1.8 x 3.6-m spacing with trickle irrigation and were trained to the vertical axis system. The treatments applied in a randomized complete-block design with four replications were an untreated control; carbaryl (Sevin XLR at 125 mL/100 L); NAA at 2.5 ppm, 5 ppm, or 7.5 ppm; NAA at 2.5 or 5 ppm plus carbaryl; and Accel (a.i. at 74 $\text{g}\cdot\text{ha}^{-1}$) plus carbaryl. Chemical thinners were applied to drip with an air-blast sprayer, when the largest fruit were 11.5 mm in diameter. Generally, thinning activity increased with increasing NAA concentration. The combination sprays of 5 ppm NAA plus carbaryl, and Accel plus carbaryl over-thinned 'Honeycrisp'. Carbaryl alone was inconsistent. All thinning

treatments increased fruit size relative to unthinned trees, with average fruit diameter exceeding 76 mm. 'Honeycrisp' is a large-fruited cultivar that is easy to thin chemically at the traditional 10- to 12-mm growth stage. NAA at 2.5 or 5 ppm provided adequate thinning to produce fruit of good quality and size. If initial set is heavy and a stronger thinning response is desired, the combination of 2.5 ppm NAA plus carbaryl could be used. 'Honeycrisp' appears to be very sensitive to Accel, when used in combination with Sevin XLR. Further research needed before Accel is used to thin 'Honeycrisp'.

271 Gibberellic Acid Effects on 'Hamlin' Orange Peel Quality are Reduced by Wash-off Sprays

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In Florida, gibberellic acid (GA_3) is applied to citrus in the late summer or early fall to reduce senescence-related peel disorders of fresh fruit and to increase juice yield of processing oranges. Heavy rainfall may occur daily during this time that could reduce the efficacy of GA_3 sprays. Experiments were conducted in 1998–99 and 1999–2000 to test the effect of timed "wash off" treatments on the peel color and peel puncture resistance (PPR) of 'Hamlin' orange (*Citrus sinensis* [L.] Osb.) fruit that were previously treated with GA_3 . In Oct. 1998 and 1999, the canopy of 14- or 15-year-old trees were sprayed to runoff (≈ 10 L) with GA_3 (45 g a.i./ha) and a non-ionic surfactant (Silwet, 0.05%). For the next 4 (1998–99) or 5 (1999–2000) h, three different GA_3 -treated trees each hour were then sprayed with ≈ 20 L of tap water to simulate rainfall that might remove or dilute the GA_3 . An additional three trees did not receive a GA_3 or a washoff treatment. Fruit were harvested in Nov. 1998 and Jan. 1999 and Dec. 1999 and Jan. 2000 and evaluated for PPR and color. Data were subjected to regression analysis to determine the relationship between peel variables and time until washoff. In 1998–99, PPR and peel hue (level of green color) increased linearly with time until washoff, indicating that some GA_3 uptake was still occurring after 4 h. In 1999–2000, PPR and hue increased linearly until about 3 h before washoff. Therefore, heavy rainfall within 3 to 4 h of application may reduce GA_3 effectiveness, even when a surfactant is used.

272 Chemical-thinning Asian Pears

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Asian pears bloom profusely and require early hand-thinning to produce large saleable fruit. In 1998, 'Shinko' and 'Hosui' trees were sprayed with Accel, Ethrel, NAA or carbaryl when average fruit diameter was ≈ 9 mm. Superior oil was added to all treatments at the rate of 2.5 mL/L. Fruit set was reduced 40 to 70% by Accel at 84 ppm and ethephon at 678 ppm, but NAA at 8 ppm and carbaryl were less effective. In 1999, Accel was applied at a range of 0 to 105 ppm and ethephon was applied at a range of 0 to 678 ppm. All treatments contained carbaryl and oil. Fruit set/100 flower clusters declined linearly with increasing ethephon concentration on 'Shinko', but was not tested on 'Hosui'. Fruit/100 blossom clusters declined linearly with increasing Accel concentration on 'Shinko'. On 'Hosui' Accel reduced fruit set by more than 40%, but treatments did not differ significantly (5% level) from the control. In both years 'Shinko' was easier to thin than 'Hosui'.

273 Changes in Polyamine Content in Grape Buds during Budbreak Induced by Thidiazuron

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The effect of thidiazuron (TDZ) at 0, 150, 300, and 450 $mg \cdot L^{-1}$ in 'Perlette' grape cuttings after chilling treatments (0, 150, 300, and 450 chill units, CU) on polyamine content and budbreak was studied. In addition, the treatment 300 CU + 300 $mg \cdot L^{-1}$ TDZ + 50 $mg \cdot L^{-1}$ GA_3 was evaluated. The results indicated that, from 0 to 6 days after treatment (DAT), putrescine (Put) content was low (50–80 $nmol \cdot g^{-1}$ FW) regardless of treatment, but it reached an average of 600 $nmol \cdot g^{-1}$ FW in both 150 CU + 300 $mg \cdot L^{-1}$ TDZ and 300 CU + 300 $mg \cdot L^{-1}$ TDZ FW treatments, at 12 DAT. These treatments had the highest bud fresh weight (BFW) (122 mg) and final budbreak (82%). Spermidine (Spd) content remained almost unchanged in the above mentioned treatments (20–30 $nmol \cdot g^{-1}$ FW) showing the highest value at

6 DAT. Spermine (Spm) content declined from 100 to 80 $nmol \cdot g^{-1}$ FW from 0 to 6 DAT remaining almost constant until the end. Neither Spm nor Spm showed clear relationship with either BFW or budbreak. Control treatments and treatments with GA_3 included had an average of 100 $nmol \cdot g^{-1}$ FW of Put throughout the evaluation period and showed the lowest BFW (≈ 45 mg) and budbreak ($\approx 30\%$) compared to the rest of the treatments.

274 Peach Floral Budbreak as Affected by Foliar Nitrogen Sprays and Girdling

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The purpose of this research was to investigate the effect of 1% N foliar sprays (0, 2, and 4 sprays at weekly intervals) and girdling (G) on budbreak of three peach advanced selections CP95-1 °C, CP91-8, and CP91-17, and its relationship with both reduced nitrogen (RN) and polyamine contents. Foliar N was applied in July, before flower initiation was detected and girdling was performed 30 days after nitrogen sprays (DAT). The results indicate that 4N+G treatment had the highest content of (RN) with values between 232 and 1000 mg N/g of DW. CP 91-17 and CP95-1 °C selections showed higher RN content than that of CP91-8. Both 2N+G and 4 N+G showed the highest content of putrescine (Put) (908 and 1635 $nmol \cdot g^{-1}$ FW, respectively). Among peach selections CP91-8 was the one with the highest content of Put. Putrescine content went down as the flower differentiation process evolved. Four N+G treatment promoted budbreak in CP95-1 °C advancing it in 55 days as compared to the control. Budbreak began earlier in the three peach selections treated with 4N+G (11/12/98) followed by 2N+G treatment (7/001/99), and the control (4/02/99). Fruit set was 19%, 12%, and 11% for 4N+G, 2N+G, and control treatments, respectively.

275 Effect of Fruit Quality, Ethylene Evolution, and Storage in Apple 'Tsugaru' as Influenced by Aminoethoxyvinylglycine and Several Surfactants

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This experiment was conducted to evaluate the effect of fruit quality, ethylene evolution, and storage in apple 'Tsugaru' as influenced by aminoethoxyvinylglycine (AVG) and several surfactants. When treated with AVG + Silwet L-77, there was little significant difference in soluble solids and acidity as compared with control, but dichlorprop treatment was significantly increased in soluble solids and decreased in acidity. Color development was decreased when treated with AVG + Silwet L-77. AVG + Silwet L-77 treatment decreased ethylene evolution, and increased storage. It can be concluded that fruit can be left on trees longer and still maintain storability, and more fruit is able to go to fresh market from long-term storage, which increases the marketability of apple.

276 Fall Ethephon Applications Delay Bloom of 'Climax' Blueberry

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'Climax' blueberry is a major cultivar in Georgia, but because of its excessively low chilling requirement and early blooming habit, it has a poor cropping history in recent years due to spring freezes. Research was initiated to explore the potential for ethephon to delay bloom, without delaying ripening too much. In 1997–1998 a treatment of 200 ppm ethephon applied on 3 Nov. or 400 ppm applied on 17 Nov. delayed bloom 5 to 7 days compared to the control. There was no significant difference between the control and the ethephon treatment in flower bud density or fruit density in the spring. In 1998–1999 ethephon applications at 200 and 400 ppm were applied once or twice 2 weeks apart starting on 5 Oct. and ending 19 Nov. A bloom delay of about 7 days was achieved with most ethephon applications. However, an application of 400 ppm on 19 Oct. and 2 Nov. delayed bloom about 14 days compared to the control. There was a trend toward delayed fruit ripening with the most-effective bloom delay treatments, but the extent of delayed ripening was minimal. Berry weight was not affected by ethephon treatments.

Effect of Pruning Method on Yield and Quality of 'Sunbelt' Grapes Grown in the San Joaquin Valley of California

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'Sunbelt' is a juice grape cultivar developed by the Univ. of Arkansas. This cultivar produces 'Concord'-type juice and is adapted to climatic conditions of the southern United States. Preliminary evaluation showed that 'Sunbelt' has potential to produce high-quality juice under the hot climatic conditions of the San Joaquin Valley. A study was conducted during the 1998 and 1999 seasons to further evaluate the adaptation of 'Sunbelt' to San Joaquin Valley conditions and determine the response of this cultivar to selected pruning methods. Vines of uniform vine size and vigor were subjected to four pruning treatments: severe hand-pruning (60 to 80 nodes retained/vine); moderate hand-pruning (120 to 160 nodes retained/vine); machine-pruning (160 to 180 nodes retained/vine); and minimal pruning (200 to 400 nodes retained/vine). Vines were trained to a Geneva Double Curtain trellis system. Yield and components of yield were significantly impacted by pruning treatment. In both seasons, mechanized systems of pruning (machine or minimal) produced higher yield than hand pruning. Minimal pruning resulted in the highest yield in 1998, while yield from machine-pruned vines was highest in 1999. Minimally pruned vines had the highest clusters/vine, lowest cluster weight, and lowest berry weight among the treatments. Fruit composition was also affected by pruning treatment. Minimal pruning produced fruit which was less mature than fruit from the other treatments in 1998. This result was likely due to the high yield obtained. Few differences in fruit composition were observed among treatments in 1999. The effect of pruning method on processed juice quality will be presented. Acceptable juice quality was obtained for most treatments.

150 POSTER SESSION 19 (Abstr. 278–306) Crop Production Wednesday, 26 July, 1:00–2:00 p.m.

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A Ratoon Cropping System for Fall Bell Pepper Production

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Studies were conducted to examine the effects of pruning treatments applied to spring-transplanted bell peppers (*Capsicum annuum* L.) on marketable fruit yield in late summer and fall. Control plants were set in the field in early May 1997 (Oklahoma) and Apr. 1998 (Oklahoma and Texas) and were harvested weekly into October (Oklahoma) or periodically into December (Texas). In 1997, there were no differences in total marketable fruit weight among four treatments involving height and method of pruning, but all reduced total marketable fruit weight relative to the control. In Oklahoma in 1998, the control was compared to plants mowed on 27 July at an average height of ≈24 cm. Mowed plants produced less total marketable fruit weight but more U.S. Fancy fruit than control plants. Also, control and mowed plants did not differ in weight of U.S. no. 1 fruit. In Texas in 1998, the control was compared to plants mowed on 4 Sept. at a height of ≈20 cm. Mowed plants produced more than double the weight of U.S. no. 1 fruit and fewer cull fruit than control plants. Nonpruned transplants set in the field in Summer 1998 (Oklahoma and Texas) gave low marketable yields. Maintaining spring-transplanted bell peppers is a viable technique for fall pepper production, and the highest total marketable yields may occur if these plants are not mowed. However, mowing offers an opportunity for increased fall production of premium fruit, and mowed plants would be easier to manage than unpruned plants.

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Planting Systems Influence Growth Dynamics and Quality of Fresh Market Spinach

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This study was conducted to determine the effect of within-row plant spacing and mulching on growth, quality, and yield of an experimental semi-savoy spinach (*Spinacia oleracea* L.) genotype 'Ark-310' to produce a high-quality fresh-market product. Spinach transplants were established in the field on 13 Nov. 1995 and 3 Dec. 1997. Within-row spacings were 15 and 25 cm, and mulching treatments were bare-soil and black polyethylene mulch. Plants were destructively sampled weekly (1996) or bi-weekly (1998) for leaf area (LA), leaf number, leaf dry weight (LDW); and root dry weight (RDW) measurements. Plants grown on plastic mulch at 25-cm spacing had the greater LA, LDW, and RDW than when grown at 15-cm spacing on mulch or bare-soil. Leaf number and specific leaf area (LA/LDW) were less affected by either spacing or mulching. The amount of soil on harvested leaves was lowest on plants grown on plastic mulch in both years. In one year, total yields (MT/ha) were 42% higher when plant spacing decreased from 25 cm to 15 cm, while mulch increased yields by 20 %, a response that was independent of plant spacing. These effects were not evident in the year with higher rainfall. It appears that for a root-cut or loose leaf spinach, yield efficiency and product cleanliness of 'Ark 310' spinach may be further improved by combining high plant density with efficient irrigation and fertilization programs under mulch and drip.

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Production of Carrots Suitable for Cut-and-peel Processing in Ontario, Canada

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Production of carrots for cut-and-peel processing has increased to >400 ha in the past 5 years in the Holland/Bradford Marsh area (44°5' N, 79°35' W) of Ontario. To provide carrots best suited for the new industry, growers needed information on the best cultivars and production practices. Trials with cultivars from four seed companies were conducted on muck soil (60% organic matter, pH 6.0) for 3 years (1997–1999) and on mineral soil (5% organic matter, pH 7.2) for 2 years (1998–1999). Carrots were seeded on raised beds at three seeding rates—25, 40, and 55 per foot—at two or three seeding dates and were harvested at two or three dates at 15-day intervals. Plant stand was always less than the seeded rate because of hot, dry growing conditions during the years of the trials. Carrots were hand-harvested and assessed for total yield, marketable yield, oversized carrots (>0.75 in diam.), length, width, and uniformity. The seeding rate of 55 seeds/ft and harvest 100 to 110 days after seeding resulted in the highest yield of carrots suited for cut-and-peel processing. Cultivar HMO3 consistently had the highest score for quality, but low yields. Other cultivars, such as 'Indiana', 'Caro Pride', and 'Vita Treat', also had high scores for quality. Carrots grown on mineral soil were longer than those grown on muck soil; however, yields were higher for the muck-grown carrots.

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Impact of Plant Population, Nitrogen, and Variety on Early Fresh-market Sweet Corn Quality

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Early fresh-market sweet corn expressed concern is prone to variability in ear length and quality due to uneven germination rates in cooler soils, smaller plant size of early corn, and single ear per stalk trait of early varieties. In an informal survey of current practices, growers reported using in-row spacings between 0.5 and 0.25 m (0.76 m between rows) for their first bare-ground corn, representing a range of plant populations from 86,000 to 43,000 plants/ha. However, no information had been gathered on the impacts of these various in-row spacings on early corn ear length and overall quality and how different sweet corn types (*se*, *sh2*, sweet breeds) might respond to these spacings under cool conditions of early spring. Four trials were conducted over the last 2 years, in upstate New York, examining three sweet corn types, five plant populations, and two nitrogen sidedress rates for effect ear length, quality, and uniformity. In general, results thus far indicate that all three parameters can influence ear quality and variability. Among treatments, ear length varied by up to 1 cm. The variety 'Sweet Symphony' was less affected by high populations than 'Temptation'. In 1998, no difference in

ear length due to spacing was found. It is suspected that the warm spring in 1998, coupled with adequate moisture, reduced plant stress during early growth. Higher nitrogen sidedress rates reduced variability of early season corn, at all populations. In 1999, plant population was found to be the most important factor affecting ear physical characteristics.

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Vegetable Yields under Sustainable Production Systems

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This experiment was designed to compare best management practices for conventional and conservation tillage systems, chemical IPM vs. organic vegetable production, and rotation effect on tomatoes. Three vegetables were grown under these management practices with sweet corn (1st year) and fall cabbage or cucumber (2nd year), and fall cabbage on half of the field plots and tomatoes on the other half. The treatments were: 1) conventional-tillage with chemical-based IPM; 2) conventional-tillage with organic-based IPM; 3) conservation-tillage with chemical-based IPM; 4) conservation-tillage with organic-based IPM; and 5) conventional-tillage with no fertilizer or pest management (control). This poster describes sweet corn, cabbage, and cucumber yields from the various treatments over two 3-year rotations. Sweet corn yields were 34% higher in treatments with chemical fertilizer and pest control than with organic methods. Ear worm damage was high (58%) in the organic treatment compared to the chemical IPM program (14%). Fall cabbage was planted after sweet corn and cucumber harvest (all treatments were reapplied). Marketable cabbage yields were in the order: conventional-tilled-organic > strip-tilled-chemical > conventional-tilled-chemical > strip-till-organic > control for both years. Percent culls (< .9 kg heads) were in reverse order of marketable heads. Cabbage insect control was similar in chemical IPM and organic management. Cucumber yields were in the order: conventional-tilled-chemical > conventional-tilled-organic = strip-till-chemical > strip-tilled-organic > control for both years. Insect damage on cucumber fruit was 51% for organic systems and 1% for chemical methods of production. No differences were seen between tillage system within the same production system (chemical vs organic).

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Water and Nutrient Management of Garlic in California

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Garlic is a cool-season vegetable crop with a long growing season. The potential nutrient and water needs are high. Irrigation and fertilization trials were conducted in the San Joaquin Valley in varying weather and different soils. Objectives were to relate fertilizer and irrigation management to garlic yield and to the efficiency of water and fertilizer use; to develop crop coefficients relating crop ET to reference crop ET; to relate postharvest quality to water nutrient management; and to determine if slow-release nitrogen fertilizers are as effective as more soluble forms. N, P, and K rates and timing of applications were applied. Furrow irrigation variables included calendar timing, cutoff date of last irrigation, irrigation at different available soil moisture (ASM) depletion, and irrigation based on evapotranspiration. A line source sprinkler irrigation was also conducted. Response to fertilizer nitrogen and to irrigation were dependent on soil type and depth. Response in heavy, deep soil was poor; response in lighter texture and shallower soil was much greater. Garlic extracted water and nutrients to depths greater than 120 cm and suffered no yield loss at high ASM depletion (50%) in deep, heavy soil. In shallow or lighter texture soil, extraction was limited to 60 cm, with highest yields when irrigated at 25% ASM depletion. Yield and quality of garlic were affected by irrigation cutoff date. Nitrogen response varied from ≈100 to more than 300 kg/ha. Slow-release nitrogen fertilizers were effective, but not economical. Little or no response to P or K fertilizer was measured in these experiments. Effects of excessive fertilizer rates on postharvest quality was variable.

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Comparison of High- and Low-input Production Schemes in Pumpkins

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Pumpkins are Ohio's third-largest fresh-market vegetable crop. Many non-

traditional growers are planting pumpkins to increase gross income. Experienced growers have noticed that new producers are successful with low input. Are intensive production practices needed for a good crop? High and low input production schemes were studied, over 3 years on pumpkin yield and quality. High input consisted of Furadan at planting, reflective mulch, trickle irrigation, and a routine fungicide and insecticide spray program. Low input consisted of no mulch, no supplemental irrigation, and a reduced fungicide and insecticide program. The number of insecticide plus fungicide sprays for high vs. low input were: 10 vs. 5 in year 1; 5 vs. 3 in year 2; and 12 vs. 8 in year 3. Number and weight of marketable orange fruit in high-input plots were significantly higher than low input plots in year 1 and 3. Plastic mulch conserved soil moisture and resulted in 91% plant stand in high input vs. 57% in low input in year 1. The only year without a significant yield difference was when the difference in pesticide sprays was two. High input is suited for retail markets where the expectation is good yields of high quality pumpkins. Wholesale producers can probably get by with reduced inputs in certain areas.

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Some Polyethylene Mulches Increase Root Numbers in Peppers

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In 1999, 'Sweet Banana' pepper plants were grown under clean cultivation or SMR—red, silver, or black polyethylene mulches. Plants in each of three replications per treatment were field-set on 15 June. On 22 Sept., plants were excavated, and their root systems were examined. The total number of roots per plant at 5-, 10-, 15-, 20-, and 25-cm depths and 10-, 20-, 30-, 40-, 50-, and 60-cm distances from plant stems were recorded. Distribution and architecture of the root systems also were examined. Plants grown under clean cultivation developed 50 to 60 adventitious roots each, while those grown under red mulch developed about 20, and those under black and silver mulch about nine adventitious roots each. In all treatments, the adventitious roots radiated from the stem at an oblique, downward 35° angle. No plants had vertical roots. Root system architecture was similar among treatments, with 40% of the roots in the upper 5 cm of soil and 70% in the upper 10 cm. Thirty percent of roots were within 10 cm of the plant stem, and 50% were within 20 cm. Nearly 100% of the roots were located within 40 cm of the plant stem. Root count decreased with increasing depth and distance from the plant stem. Plants grown beneath the silver mulch produced the greatest number of lateral roots, followed by plants grown in clean cultivation and under black mulch. Plants grown under red mulch produced the fewest roots. Differences among treatments were significant. Colored mulches influence the total number of adventitious and lateral roots but not the root system architecture of pepper plants.

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Effects of Different Mulching and Tillage Systems on Soil Water Retention Under Drought Conditions in a Tomato Production System

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Water management is often the key to successful vegetable culture. Various mulching/tillage systems are often utilized in tomato production, depending upon the available resources of a particular grower, to achieve better water use efficiency. A study was conducted to compare six different mulching/tillage systems to observe the influence of these systems on soil water retention as well as on 'Fabulous' tomato (*Lycopersicon esculentum* Mill.) production. Winter ryegrass and wheat were the cover crops utilized and were mowed with the following six treatments then applied: 1) Conventional tillage (CT), 2) black plastic over conventional tillage (BP), 3) no-till with cover crop sprayed with Glyphosate prior to transplanting (NT-GLY), 4) strip-till with cover crop sprayed with Glyphosate prior to transplanting (ST-GLY), 5) no-till in which cover crop was mowed periodically during the growing season (NT), and 6) strip-till with cover crop mowed periodically during the growing season (ST). This test was conducted under severe drought conditions (45.4 mm of rain from 1 July to 30 Sept. 1999) with plants receiving no supplemental water via irrigation at any time throughout the study. Soil moisture was measured periodically throughout the growing season at a depth of 20 cm; soil and mulch surface temperatures were taken at similar timings as soil moisture. Soil moisture levels during the growing season indicated

different patterns of water depletion when comparing the six treatments. There was no significant difference between the winter rye and wheat with respect to water depletion or tomato yields. Lower early tomato yields under NT, ST, NT-GLY, and ST-GLY indicate that cooler soil conditions, while aiding in the retention of soil moisture, delay early tomato production when compared to the warmer soil conditions found under CT and BP. Results also indicate that late season harvests under NT and ST systems produce predominantly cull fruits with a high incidence of blossom-end rot. The NT-GLY and ST-GLY systems tended to produce comparatively lower levels of cull fruit and blossom-end rot in late season harvests than any of the other six treatments.

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Exclusion of End-of-day Far-red Light by Photosensitive Plastic Films Reduces Height of Cucumber Seedlings

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The far-red light intercepting photosensitive plastic greenhouse covers have been shown to be effective in producing compact vegetable transplants. However, photosensitive films reduce the photosynthetic photon flux (PPF) transmission compared to conventional plastic films because of the dye contained in the film. The low PPF in greenhouses covered with photosensitive films may result in decreased plant dry matter production and could especially be a problem in the season with low light level and in northern latitudes. Therefore, this study was conducted to determine if covering at the end of the day (EOD) with photosensitive films was effective in controlling height of vegetable seedlings. This will allow growers to maintain a high light level during daytime for optimum growth of plants. Cucumber seedlings were exposed to light transmitted through a photosensitive film and a clear control film. Three exposure durations: continuous, exposure to filtered light from 3:00 pm to 9:00 am, and from 5:00 pm - 9:00 am, were evaluated. Results show that, after 15 days of treatment, about 25% of height reduction could be achieved by exposing the plants at the EOD from 3:00 pm to 9:00 am or from 5:00 pm to 9:00 am. Plants grown continuously under filtered light were the shortest. Compared to plants grown in photosensitive chamber continuously, EOD exposed plants had greater leaf, stem and shoot dry weights, greater leaf area and thicker stem. Specific leaf and stem dry weights were also greater in EOD exposed plants. Number of leaves was not significantly affected by any exposure periods tested. The results suggested that the EOD use of photosensitive film is effective in reducing height of cucumber seedlings. The responses of other crops need to be evaluated to test the feasibility of using photosensitive film as a EOD cover on wide range of crops.

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Use of Transplants, Rowcovers, and Black Plastic to Improve Yield and Earliness of Butternut and Calabaza Squash

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The population of Puerto Ricans and Dominicans in Massachusetts is ≈6% of the total state population. Latinos have begun to request certain commodities native to their culture at Farmers' Markets and retail stores. One of these commodities is a winter squash [*Cucurbita moschata* (Duchene Poir)] called calabaza in Puerto Rico and ayama in the Dominican Republic. Calabaza has also been found in Asian markets. In order to have the crop ready for market by August in the Northeast, cultural practices which hasten maturity would need to be used. Eight treatments were tested: 1) direct seeded in bare ground, 2) direct seeded in black plastic, 3) direct seeded in bare ground with rowcover, 4) direct seeded in black plastic with rowcover, 5) transplanted in bare ground, 6) transplanted in black plastic, 7) transplanted in bare ground with rowcover, 8) transplanted in black plastic with rowcover. Calabaza was compared to butternut squash. Three weeks after seeding or transplanting, the transplants on black plastic were just beginning to vine and those transplants on black plastic and covered with rowcover were vining and in flower. Direct-seeded plants were in the second- or third-leaf stage. Treatment effects on early growth in the spring translated to differences in earliness and yield at the end of the season. Overall, the use of transplants improved yield by 30%, black plastic improved yield 15%, and the use of rowcover improved yields by 12%. There were no significant differences among the treatments where transplants were used along with plastic, rowcover or both. Significant differences were found in the number of fruit available for harvest in August.

Direct-seeded plants on bare ground or on plastic did not have any harvestable fruit in August. The transplant, plastic and rowcover treatment had 300 to 500 boxes/acre depending on the year. Even the use of transplants on bare ground yielded an August-harvested crop.

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Effect of Swine Effluent on Yields of Plasticulture-grown Vegetables

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Five fertilizer treatments, three of which included swine effluent alone or in combination with commercial fertilizers, were evaluated for plasticulture production of vegetables. Effluent and/or soluble fertilizers were delivered through drip irrigation tubing to their respective treatments. Four experiments were conducted at two locations: 1) spring tomatoes followed by pumpkin at Verona, Miss., 2) spring tomatoes followed by zucchini at Pontotoc, Miss., 3) fall tomato at Verona, and 4) fall tomato at Pontotoc. In all four experiments, representing six crops, yields from treatments receiving swine effluent were equal to or greater than yields from treatments receiving preplant fertilizers and/or commercially available soluble fertilizers. There were also no significant differences among treatments in relative number of marketable fruit. Leaf tissue analysis of the tomato crops showed no significant differences among treatments in N content. For some experiments, there were significant differences for other elements. These results showed that swine effluent was an effective nutrient source for plasticulture production of vegetable crops when compared to preplant and soluble fertilizers. These results also showed that the alkaline pH (about 7.8) and high level of ammonium nitrogen of swine effluent (>95 % of N content) did not adversely affect vegetable yield or marketability.

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Potassium Fertilizer and Soil Nutrient Status Affect Internal White Tissue Severity and Influence Fruit Quality in Ohio Processing Tomatoes

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A significant portion of the Great Lakes region's processing tomato crop is used to make whole fruit and diced products, where fruit color and textural uniformity are important. Soil and fertilizer studies were undertaken to better understand the role of soil fertility and potassium application on the color disorder known as internal white tissue (IWT) under this region's conditions and in area soils. During 2 years of replicated potassium rate trials in Ohio, tomato yield was not significantly altered by broadcast potassium applications. Potassium application rate was inversely correlated with frequency and severity of IWT in each season, and positively correlated with titratable acidity. The ability of split applications to influence IWT severity was not significantly different than that of preplant applications. IWT symptom frequency and severity was correlated with elemental concentrations in the fruit, leaves, and soil. In 1998, severity of IWT symptoms was positively correlated with shoulder tissue calcium and sodium concentrations, and negatively correlated with concentrations of phosphorus, magnesium, and nitrogen. Correlations for other nutrients, including potassium, were less clear. A companion study of six grower fields during the second year, using grid sampling techniques and the IWT-susceptible Peto 696 cultivar, found significant variability of IWT symptoms within and among fields. Variability within fields was correlated with soil nutrient concentrations. These data indicate researchers may be able to develop recommendations for field mapping and precision management strategies that can reduce the levels of IWT for area growers.

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Light-filtering Film Reduces Tomato Seedling Height Without Altering Fruit Quality and Yield

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There is significant interest in using non-chemical methods to control seedling height in vegetable transplant production. One method being evaluated is the use of greenhouse films that filter significant amounts of far-red light from ambient light, resulting in shorter transplants. This study was undertaken to evaluate

fruit yield and quality of field-grown tomatoes produced from seedlings grown under light-filtering plastics. Tomato seedlings were grown under clear polyethylene tents or light-filtering laminate tents in a polyethylene-covered Quonset greenhouse in northern Ohio. Standard 288 deep plug trays, filled with MetroMix 360, were used. Seedlings were placed under the tents at the cotyledon stage and transplanted 28 days later. Once in the field, they were grown as staked plants under open conditions using locally accepted horticultural practices. Differences in seedling height were detected within a few days after being placed under the tents. Compared to those grown under clear polyethylene tents, seedlings grown under the light-filtering plastic increased in height more slowly and were shorter at transplanting. At harvest, within each of the three cultivars tested, no significant differences in fruit number, yield, or mean fruit size were found between treatments. It is inferred that this non-chemical method for reducing vegetable transplant height may be a viable production option in the future.

292 Effect of Pre-plant Application of VAM and Particle Film Applications on Tomato in a Supra-optimal, Semi-arid Environment

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A reflectant particle film material, 'Surround', which also has biocide properties, and mycorrhizal root inoculation of tomatoes at transplanting were evaluated for their efficacy in improving tomato plant water status and agronomic performance in a supra-optimal, semi-arid environment. Seven-week-old 'Heatmaster' tomato plants (*Lycopersicon esculentum* Mill.) were transplanted with or without a VAM inoculant (Gomes intradices, Schenk & Smith) on 19 Feb. 1999 into a Raymondville clay loam soil in Weslaco, Texas (Lat. 26°12'). One-half of the inoculated and one-half of the uninoculated plants were sprayed between 16 Mar. and 1 June with seven applications of 'Surround.' The trickle-irrigated plots were 5.6 m² in size and treatments replicated four times in a RCB design. Recommended cultural practices were followed, but no fungicides were used. Results indicated that mycorrhizal treatment tended to accelerate fruit maturation and that particle film applications delayed fruit development relative to the control treatment. Mycorrhizal-treated plants had the highest yields at the second (of eight) harvest compared to the other treatments. There were no significant differences between treatments in leaf temperature, diffusive resistance, transpiration rate, water potential, and soil profile moisture, except between sampling dates. Fruit mineral nutrients, pigments, dry matter, average weight, total marketable and total season yields were not significantly effected by any treatment. When fruits were sectioned into proximal and distal halves, 10 out of 14 nutrients measured, in addition to dry matter, and total carotenoids were higher in the distal end.

293 Potential Allelopathy of Sorghum–Sudan Mulch

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Observations that tomato transplants died or were severely stunted when set into unincorporated sorghum–sudan hybrid surface mulch led us to further investigate the potential allelopathic impacts of this warm-season cover crop in a series of field experiments. Survival and dry weights of tomato, lettuce, and broccoli transplants were determined in fallow, incorporated sorghum–sudan-, and unincorporated sorghum–sudan-mulched soils. All three species transplanted into plots in which the sorghum–sudan had been cut and left on the soil surface had a significantly lower dry weight than plants transplanted into fallow soil or into soil where the sorghum–sudan had been incorporated. Additionally, fewer transplants survived in the mulch treatment. The surface mulch plots also significantly reduced weed biomass nearly 10-fold. We believe that a water-soluble compound that is leached out of the sorghum–sudan hybrid is toxic to all three of the plants tested. Further laboratory and greenhouse tests are under way to determine the exact nature of the toxic substance.

294 Comparative Studies of Local vs. Imported Tomato Cultivars under Saline Irrigation Water

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Scarcity and high cost of good-quality water for irrigation in the Kuwait environment, which is located in an extremely arid region, necessitate the utilization

of underground brackish water. However, productivity of most vegetable crops is reduced tremendously when irrigated with such low-quality water. Consequently, a tomato-breeding program had been launched to develop tomato cultivars that are well-adapted to the local conditions. The present work is a 2-year field study to compare the performance of four locally developed vs. eight imported tomato cultivars under saline irrigation water (brackish). The experiment was laid out in a completely randomized block design with four replications. Dimensions of each experimental unit was 2 x 2.5 m (5 m²). Fertilization and other cultural practices followed those recommended for the local environment and soil was sandy in texture. Prior to transplanting seedlings to field, they had been irrigated with nonsaline water. Total dissolved solutes of the brackish water used for irrigation was 7500 mg.L⁻¹. A total of seven harvests were collected on a weekly basis. There were no significant differences among tomato cultivars in terms of total fruit weights in the first four harvests. However, beginning with the fifth harvest, two of the locally developed cultivars (Kuwait-16 and Kuwait-20) were among the highest in total yield for two consecutive years in this study. It is therefore recommended that these Kuwaiti tomato cultivars be used to replace the several expensively imported varieties, which, though high yielding, are not necessarily so in the Kuwait environment, or may be salt-sensitive cultivars. Combining the local varieties with the use of less expensive brackish water could reduce the expense of farming significantly in this region of the world.

295 Controlling Crop Growth Media Moisture with Sensors

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Tight control of growth media moisture content is needed when plant growth systems employ shallow root zones or for cultivating fast-growing plants (i.e., crops). Poor control of moisture can affect both growth rate and plant quality by either excessive watering (waterlogging) or drought events. We evaluated the performance of two types of moisture sensors: tensiometers and heat-pulse moisture sensors. The output from each sensor type was evaluated as a function of volumetric moisture content in 1 to 2 mm Turface. The tensiometers were more sensitive between 30% and 60% volumetric moisture content, and their output was nonlinear because they measure water potential directly. In contrast, both the sensitivity and the output of the heat-pulse moisture sensors, as a function of volumetric moisture content, were linear. The heat-pulse moisture sensors were used to control moisture content in a shallow root zone, whereby water was added or removed from the media through a porous tube using peristaltic pumps. Moisture content in the media could be maintained within ±2% of setpoint for moisture contents ranging from 20% to 100% volumetric moisture content. The heat-pulse sensors were better suited for controlling media moisture because of their linear output and because of their constant sensitivity as a function of volumetric moisture content.

296 Study of Water Applied on Two Varieties of Honeydew Melons with a Drip Irrigation System

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In the Caborca area, water scarcity is the main problem for the farmers, because of the depletion of the aquifer. This is the main reason why they are focusing on orchards and vegetables. Melon is the vegetable annual crop more extensively grown in this area and is furrow-irrigated with 120 cm of water. But, because of the scarcity of water, it is necessary to use drip irrigation. The objective of this study was to validate in a commercial field (15 ha) the effects of drip irrigation system on the water use, yield, and quality of two honeydew melon varieties (green flesh and orange flesh) in the Caborca area. Our results indicate that, with 50 cm of water applied, yields were 2146 to 2802 boxes/ha for green flesh and orange flesh, respectively. The predominant sizes were 4s and 5s with 25% and 38% for green flesh, and 5s and 6s with 42% and 36% for orange flesh. These sizes are the best for the exportation market.

297 Study of the Regular and High Application of Water with Drip Irrigation in Asparagus

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Asparagus production in the past years has been increasing very rapidly and now totals 5000 ha. The main problem in this zone is the depletion of the aquifer

and it is important to use this resource carefully. During 1999, an experiment of drip irrigation in asparagus was conducted. Three treatments were applied: 50%, 75%, and 100% of the evaporation from a pan evaporation type A. The results of the statistical analysis indicated that the best treatment was 100% with a yield of 517 boxes/ha and 183 cm of water applied. The lowest yield (290 boxes/ha) was with 50% and 91 cm of water applied.

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Biosolids and Soil Solarization Effects on Bell Pepper (*Capsicum annuum*) Production and Soil Fertility in a Sustainable Production System

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Methyl bromide will be unavailable to conventional vegetable growers in the year 2005, and it cannot be used by organic growers. Chemical alternatives are more expensive and may also be subject to future restrictions. Non-chemical alternatives like solarization and organic amendments are as yet largely unproven but do offer promise of sustainable solutions free of government regulation. The objective of this study was to evaluate the effects of soil-incorporated biosolids and soil solarization on plant growth, yield, and soil fertility. Main plots were a biosolids soil amendment (37 Mg·ha⁻¹) and a non-amended control. Treated main plots had received some type of organic amendment for the previous 6 years. Sub-plots were fumigated with methyl bromide as they had been for 6 years, or non-fumigated. Non-fumigated plots were further split into solarized and non-solarized plots. Bell pepper (*Capsicum annuum* 'X 3R Aladdin') was grown for 8 months. Nitrogen fertilization was reduced to 50% of the recommended rate in the biosolids plots due to expected N mineralization from the biosolids amendment. Plant biomass was higher in the biosolids plots compared with the non-amended plots but there were no differences in marketable pepper yields between biosolids and non-biosolids plots. Plants grown in solarized soil produced lower plant biomass and yields than the methyl bromide and non-fumigated treatments. Soil pH and Mehlich 1-extractable P, K, Ca, Mg, Zn, Mn, Fe, and Cu were higher in biosolids plots than in non-amended control plots. Soil organic matter concentration was 3-fold higher where biosolids were applied compared with non-amended soil. The results suggest that regular organic amendment applications to a sandy Florida soil can increase plant growth and produce similar yields with less inorganic nutrients than are applied in a standard fertilization program. However, methyl bromide and non-fumigated treatments produced higher yields than soil solarization.

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Effects of Plant Growth Regulators on Heat Stress in Annual Artichoke Production

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Artichoke is a cool-season perennial crop that is grown as an annual from seed in southern California. Growing artichokes as annuals from seed allows growers to harvest during the winter from November to March. Artichoke seed is planted in May, transplants are moved to the field in July, and harvesting begins as early as November in years with relatively cool fall weather. Hot fall weather during September and October suppresses plant growth and causes premature flowering, which lowers yield and average bud size. Plant growth regulator (PGR) treatments were evaluated in annual artichokes to determine if they could reduce the adverse effects of hot weather during September and October. Treatments included multiple applications of apogee (gibberellin inhibitor), retain (ethylene inhibitor), apogee + retain, cytokinin, and control plots. Harvestable buds were counted as a measure of earlier flowering induced by hot weather. Apogee and cytokinin show promise in reducing heat stress during hot fall artichoke production. Other PGR treatments increased the number of harvestable buds compared to control plots.

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Effects of Plant Growth Regulators on Eggplant (*Solanum melongena* L.) Yield

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Field studies were conducted in the Dominican Republic to determine the effect of several plant growth regulators on the yield of 'Jira' eggplant. Treatments

consisted of aqueous solutions of folcysteine (25, 50, 75 ppm), giberellic acid 3 (10, 20, 30 ppm), kinetine (25, 50, 75 ppm), naphthalenacetic acid (NAA) (25, 50, 75 ppm), 2,3,4-dichloro-phenoxy-triethyl-amine hydrochloride (DCPTA) (25, 50, 75 ppm), triacontanol (5, 10, 15 ppm), ethanol (5, 10, 15%), and chlormequat (50, 100, 150 ppm) sprayed at early flowering, directed to the crop upper leaves and flowers. A control treatment (no plant growth regulators applied) was also included. A randomized complete-block design with four replications was utilized. Experimental units were two rows of 10 plants at a 1.0 x 0.4-m distancing. Eggplant fruit set and yield were determined after 10 harvests performed at 3-day intervals. Analysis of variance and mean comparison tests were performed on the resulting data. 'Jira' eggplant fruit set and yield was significantly improved by folcysteine, giberellic acid 3, and NAA, but not by kinetine, DCPTA, ethanol, triacontanol, or chlormequat. Eggplant yield increased as folcysteine rate increased from 0 to 50 ppm, but no further yield increase was obtained when increasing the rate from 50 to 75 ppm. Similarly, eggplant yield significantly increased as giberellic acid increased from 0 to 20 ppm, but not when rates increased from 20 to 30 ppm. With NAA, eggplant fruit set and yield significantly increased above that of control plants when 25 ppm was applied, with no significant yield increase at higher rates. Results indicate that the yield of 'Jira' eggplants could be enhanced by the treatments with either folcysteine, NAA, or giberellic acid hereby described.

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Gibberellic Acid (GA₃) and Light Affect Germination of *Echinacea angustifolia* Seeds

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The narrow-leaved purple coneflower (*Echinacea angustifolia*) produces echinacin and related compounds in the root, which are known to have immune and curative properties against viral, fungal, and bacterial infections. In recent years, cultivation of this species has increased in response to growing market demand for natural medicinal remedies. The objective of this study was to determine the influence of gibberellic acid and light on the germination of *E. angustifolia* seeds. Seeds soaked for 24 h in 0, 1, 5, 10, 50, 100, 250, 500 or 1000 mg/L GA₃ solution were germinated on Whatman #1 filter paper inside petri dishes at 22 °C with or without light (80 μmol·m⁻²·s⁻¹) for 21 days. The seeds germinated poorly in dark with the final percent germination range from 10% (GA₃ 1000 mg/L) to 36% (GA₃ 250 mg/L). Under light, seed germination showed a quadratic response ($r = 0.84$) to GA₃ concentration. Percent germination exceeded 90% at 10, 50, and 100 mg/L GA₃ with the mean time (T₅₀) to germinate varying at 10.5, 11.7, and 13.3 days, respectively, under light. Seed germination under light was <10% when treated with 500 and 1000 mg/L GA₃. In general, seed germination was best when treated with 10 or 50 mg/L GA₃ under light. Results of this research may well be used in enhancing seed germination during field establishment of *E. angustifolia*.

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Comparative Effectiveness of Cytokinins on Quality of Soybean Sprouts

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Soybean sprouts are one of the most-favored traditional vegetables around the world. The sprouts are usually consumed 7 to 10 days after sowing depending upon the growing conditions. High-quality sprouts should have less secondary roots, short and well-swollen hypocotyls in pure white color, and small cotyledons in hooked position. Cytokinins were reported to be effective in producing such sprouts by promoting sprout growth while inhibiting the excessive hypocotyl elongation and secondary root growth. Seeds of four soybean cultivars with different characteristics were soaked in water for 4 h and, 2 to 3 h after the imbibition, the seeds were soaked again in solutions of different cytokinins such as benzyladenine (BA), BA-riboside (BAR), BPA, 2iP, 2iP-riboside, 4-CPPU, and kinetin-riboside (KR) for 10 min. After the treatment, the sprouts were grown in a plastic tube (25 cm height x 10.5 cm diameter) a dark culture room with ample watering every 4 h. After 7 days of growth, uniform samples were taken from each treatment and the sprout characteristics were examined. Some cytokinins such as BA, BAR, 4-CPPU were highly effective in promoting the sprout growth (fresh weight) even though the hypocotyl length was markedly reduced. Other cytokinins such as 2iP, 2iPR, and KR had no effect on sprout growth. Hypocotyl diameter was markedly increased by BA and 4-CPPU treatment, thus resulting in short,

strong and good quality sprouts. Cultivars responded differently to cytokinin treatment by showing different growth promotion depending upon the sprout parts. Injury-like symptoms, abnormal and twisted heads or cotyledons, appeared in cytokinin-treated sprouts at high concentrations and the symptoms were severe when the sprouts were grown at high temperatures. In all the cultivars tested, BAR appeared to be better than others in terms of sprout quality and growth promoting characteristics.

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Pre-sidedress Soil Nitrate Concentrations and Yield Response to Fertilizer Applications in Processing Tomatoes

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Overuse of chemical N fertilizers has been linked to nitrate contamination of both surface and ground water. Excessive fertilizer use is also an economic loss to the farmer. Typical N application rates for processing tomato production in California's Central Valley are 150–250 kg·ha⁻¹, and growers generally fail to fully consider the field-specific effects of residual soil NO₃-N concentration, or N mineralization potential of the soil. The purpose of this research was to determine the effects of sidedress N fertilizer application, residual soil NO₃-N, and in-season N mineralization, on processing tomato yield. Research was conducted during the 1998 and 1999 growing seasons at 16 field sites. Pre-sidedress soil nitrate concentration was determined at each trial site to a depth of 1 m, and aerobic incubation tests were conducted on these soils (top 0.3 m depth) to estimate N mineralization rate. Sidedress fertilizer was applied at six incremental rates from 0 to 280 kg N/ha, with six replications of each treatment per field. Only five fields showed yield response to fertilizer application; yield response to fertilizer was associated with lower pre-sidedress soil nitrate levels. In most fields with fertilizer response, yield was not increased with sidedress N application above 56 kg·ha⁻¹. Mineralization was estimated to contribute an average of ≈60 kg N/ha between sidedressing and harvest. These results suggest that N fertilizer inputs could be reduced substantially below current industry norms without lowering yields, especially in fields with higher residual soil nitrate levels.

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Effects of Calcium and Magnesium on Growth, Fruit Yield, and Quality of Greenhouse Tomato Grown in Rockwool

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Tomato (*Lycopersicon esculentum* Mill.) cv. Trust was grown in rockwool in summer and fall 1999 and 8 calcium/magnesium nutrient treatments, formed by two levels of calcium (Ca: 150 and 300 ppm) and four levels of magnesium (Mg: 20, 50, 80, and 110 ppm), were applied to investigate the effects on growth, fruit yield and quality. High calcium (300 ppm) increased overall fruit yield and size, reduced incidence of blossom-end rot and fruit cracking. However, high calcium also reduced the dry-matter content, soluble solid content and firmness of tomato fruit, and increased fruit russetting. Magnesium did not affect early growth or fruit production. However, 2 months after applying the treatments, the plants grown under 20 ppm Mg started to show Mg-deficient symptoms (leaf chlorosis), and Mg-deficient leaves lost more than 50% of their photosynthetic capability. The Mg concentration required for achieving high yield of firm fruit with high soluble solids and dry-matter content increased as the plant aged; i.e. 50 ppm in early stage of fruit production and 80 ppm in later stage of fruit production. At the end of experiment, the plants grown with 80 ppm of Mg also had the best root systems. Therefore, for both better yield and quality, a concentration of 300/50–80 ppm Ca/Mg may be recommended. Mg concentration may be started at 50 ppm and gradually be increased to 80 ppm in the later stage of fruit production.

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Effects of Electrical Conductivity (EC) and Its Diurnal Changes in Nutrient Feedings on Fruit Yield and Quality of Greenhouse Tomato Grown in Rockwool

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Poor tomato fruit quality in summer time (soft fruit, cracking, and russetting) is a major greenhouse production problem in North America. To improve tomato quality and yield, especially under summer conditions, four EC treatments were applied to a tomato crop grown in rockwool in summer and fall of 1999 at the Greenhouse and Processing Crops Research Centre, Harrow, Ont., Canada. The four fertigation solution EC treatments were 1) constant low EC at 2.54 mS·cm⁻¹, 2) constant high EC at 3.82 mS·cm⁻¹, 3) diurnal EC variation (1 to 5 mS·cm⁻¹) with a 24-h average of 2.54 mS·cm⁻¹ and 4) diurnal EC variation (1 to 7 mS·cm⁻¹) with a 24-h average of 3.82 mS·cm⁻¹. For diurnal EC variation, the plants were fed with low EC in the morning and around noon, and high EC in the afternoon and night. High EC (3.82 mS·cm⁻¹, constant or 24-h average for diurnal variation) treatments, in comparison to the recommended EC (2.54 mS·cm⁻¹) treatments, improved tomato fruit quality by reducing fruit cracking, and increasing percentage of grade #1 fruit, fruit firmness, soluble solid and dry-matter content. However, the constant high EC treatment resulted in smaller fruit size and lower yield. Diurnal EC variation with a high EC average (24-h average: 3.82 mS·cm⁻¹) did not reduce fruit size and yield, and reduced fruit russetting. Therefore, a diurnal fertigation EC variation strategy-supplying low EC solution in the morning and noon and high EC solution in the afternoon and night, with an overall 24-h average of 3.82 mS·cm⁻¹, may be used to improve tomato fruit quality.

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Preharvest Methods to Reduce Skinning in 'Beauregard' Sweetpotato

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The 'Beauregard' sweetpotato variety is very prone to damage to its skin. We evaluated several preharvest treatments to reduce skinning so that less damage was done at harvest, during transport, and packing. Three field tests were conducted in 1998 (two tests) and 1999 (one test) in North Carolina. Treatments were implemented 1 and 2 weeks prior to harvest and were either chemical or mechanical. The three mechanical treatments were flail mowing, flail mowing and barring off, and vine snatching. The following chemical treatments were made: PREP, Diquat, Dessicate II, and 2,4-D at various rates. Sweetpotatoes were harvested and roots were graded. Subsequently, U.S. No. 1 root subsamples were obtained from each plot in order to evaluate the effects of treatment on skin tightening of roots. Roots were evaluated from each plot for skin toughness using a "skin-o-meter" where a pressurized stream of water was directed at a sweetpotato. The roots were then evaluated for skinning by checking if the skin was broken using the skin-o-meter. A second method was used to evaluate the effect of treatment for its effect on skin tightening (reduced skinning). One bushel of roots from each treatment plot was transported to Clinton, N.C., and run through a small packing line at the Horticultural Crops Research Station the next day after harvest. The sweetpotatoes were then evaluated in Raleigh for the number of incidences where skin had been removed during the harvesting, transport, or packing process. The severity of skinning was characterized by counting the number of small (<5 mm), medium (width 5–10 mm) and large (width 10+ mm) skinned areas on a root. An overall appearance rating for roots was also recorded for each subsampled plot with 10 being the best rating and 1 being the worst. Results indicate that treatment 14 days prior to harvest rather than 7 days prior to harvest seems to be advantageous in most cases for reducing skinning and maintaining yield of sweetpotato when compared with not treating the vines. Regardless of whether the treatment was chemical or mechanical, treatments were apparently beneficial in these tests. Application of PREP 7 days prior to harvest resulted in sweetpotatoes with the most resistance to skinning in 1999, the fewest large-size skinning abrasions on roots, and best appearance. PREP shows promise as a means to reduce skinning in sweetpotatoes, but presently is not labeled for use on sweetpotatoes.

43 POSTER SESSION 6 (Abstr. 307–325)
Propagation/Tissue Culture
Monday, 24 July, 1:00–2:00 p.m.

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Growth Regulator Pretreatments Significantly Enhance the Efficiency of Shoot Organogenesis from Leaf Explants of Highbush Blueberry Cultivar Bluecrop

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As part of a program to develop transgenic highbush blueberry (*Vaccinium corymbosum* L.) cultivars, studies were conducted to determine optimum conditions for high-efficiency shoot regeneration from leaf explants of in vitro propagated, commercially important, tissue culture-recalcitrant 'Bluecrop' shoot cultures. The effects of pretreatments, growth regulators, and age of explant source on shoot organogenesis were investigated. A maximum of 98% shoot regeneration and 10 shoots regenerating per leaf explant occurred when explants of 2-week-old shoot cultures were incubated in the dark (for a total of 14 days) on pretreatment medium #1 containing 2.6 μ M NAA and 5 μ M TDZ for 4 days, next on pretreatment medium #2 containing 2.6 μ M NAA and 7 μ M zeatin riboside for 3 days, then on regeneration medium containing 1 μ M TDZ for 6 weeks, and last on medium without growth regulators for 10 days. No shoot regeneration occurred if explants were incubated without exposure to pretreatments before incubation on regeneration medium. There were no significant differences in percentage of regeneration or the number of shoots regenerating per explant from leaf explants derived from either 1-, 2-, or 3-week-old shoot cultures. Shoot production per explant on 1 μ M TDZ was about three times that on either 0.5 μ M TDZ or 20 μ M zeatin riboside, and nine times that on 5 μ M TDZ.

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Screening Strawberry in Vitro for Response to *Colletotrichum acutatum*

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As part of a program to generate anthracnose (*Colletotrichum acutatum*) resistance in strawberry (*Fragaria x ananassa* Duch.) via either tissue culture or gene transfer techniques, studies were conducted to determine whether in vitro screening for resistance to *C. acutatum* was feasible. Six commercial cultivars (Latestar, Delmarvel, Pelican, Sweet Charlie, Chandler, and Honeoye) that differed in their response to the pathogen under field conditions were tested to see whether this response was reflected in vitro. Leaves from 4-week-old shoot cultures were soaked in a spore suspension of *C. acutatum* isolate Goff, transferred to 0.5% water agar, and the presence or absence of disease symptoms was evaluated on a 0–4 rating scale after 7 days. Five of the six cultivars exhibited a disease rating similar to field results. This study suggests that there is potential to use this procedure as a screening technique, and studies are in progress to screen strawberry regenerants for resistance.

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Rapid Growth of Microbudded Citrus Planted Ultra-high Density

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High-density or ultra-high-density orchards have had positive economic return up to 12 years after planting. However, an initial higher investment on more number of trees needed is a limiting factor for high-density planting. Our preliminary studies have shown that a microbudding technique that we had developed would produce less-expensive, budded citrus trees. In June 1997, several hundred microbudded citrus trees were planted in a field, under drip irrigation. The planting continued monthly until Dec. 1997. The cultivars planted were: 'Marrs' orange, 'Rio Red' grapefruit, 'Meyer' and 'Ponderosa' lemon, and satsuma mandarin. All plants were microbudded on sour orange rootstock grown in 5" long "conetainers." Our objectives were to study the growth performance of small,

microbudded trees planted in the field. The plants grew normally and even outperformed the conventionally budded trees in a field nursery next to the test plot. In Dec. 1999, tree height reached 60 inches. Five percent of the trees produced fruit and they were normal in shape, color, and quality.

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Effect of Scionwood Moisture and Cut-end Waxing on Pecan Bark Graft Success

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Pecan is a difficult species to propagate by grafting. The whip graft, bark graft, and four-flap graft, the most often-used techniques for pecan grafting, require dormant scions, collected and stored for 60 to 120 days prior to spring-season grafting. Poor graft success is often blamed on handling and storage environment of the scionwood. Moisture content of packing material, waxing of cut ends, and use of polyethylene bags was evaluated in a controlled experiment in 1998 and 1999. Scions were cut in early February each year, and stored for 60 to 70 days in a household refrigerator under different treatment regimes. Scion viability was tested by bark grafting mature pecan trees in Fairhope, Ala., and Uvalde, Texas. In 1998, graft success rate was equally good among scions stored in polyethylene bags with different amounts of added moisture, whether cut ends were waxed or not. Moisture loss of the scions during storage was affected each year by the amount of water added to packing material and by waxing the cut-ends, but the differences did not impact graft success. An interaction of not waxing the cut ends and very wet packing material reduced graft success at Fairhope, Ala., but not Uvalde, Texas, in 1999.

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Seed Treatments, Rootstock Cultivar, and Environment Affect Peach Seed Germination

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Poor peach seed germination can be a problem for commercial tree fruit nurseries. Even standard rootstocks such as Lovell and Nemaguard do not always have high germination rates. New seed-propagated rootstocks under development, such as Guardian peach rootstock, often are selected for their field traits, with nursery characteristics being of secondary importance. Guardian rootstock is derived from bulked open-pollinated seed from a number of F₁ seedling selections. Germination of Guardian bulked seed has been poor. Four pre-stratification cold treatments were given to four 100-seed lots each of Lovell, Nemaguard, and 10 Guardian selections prior to planting each year (1994 to 1998) in a Cecil sandy loam at Musser Fruit Research Center near Clemson, S.C. Treatments included taking dry, refrigerated seed that were harvested in August and soaking 100-seed seedlots in 1500 mL perlite and 400 mL distilled water for 0 (no soaking), 2, 4, 6, and 8 weeks at 6 °C before sowing (typically early November). All treatments consisted of 25 seeds per replicate (4 reps/year) per rootstock or selection and were sowed the same day. The experiment was analyzed as a blocked split plot design with duration of stratification the whole-plot and seedlot the sub-plot. Number of emerged seedlings were counted weekly starting in January of each year. There were significant differences between stratification treatments, seedlots and years. The 6-week pre-stratification had the highest germination over 5 years and like the 8-week treatment advanced the average germination date by 20 to 30 days. Nemaguard (65%), Lovell (64%), and Guardian 3-17-7 (60%) had the best germination percent across all treatments and years, with SL2891 (42%) slightly less. All other selections averaged less than 25%. Year-to-year variation was large, indicating strong environmental influences on seed germination despite the pre-stratification treatments.

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Influence of BAP and CPPU on the in Vitro Shoot and Bud Proliferation of Apple Rootstocks M. 111 and M. 7

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This work aims to verify the effect of BAP (6-benzyladenine purine) and CPPU (forchlorfenuron) on the in vitro shoot proliferation of apple rootstock cultivars M. 111 and M. 7 under different concentrations. The experiment was carried out in

the tissue culture laboratory at Embrapa Temperate Climate in Pelotas, RS, Brazil. As initial explants, microcuttings were used from in vitro culture. The treatments consisted of the combination of two cultivars with cytokinins and six different concentrations (0.0, 1.5, 3.0, 4.5, and 6.0 μmol). The explants were inoculated in 250-mL flasks with 40 mL MS medium with agar (7.0 $\text{g}\cdot\text{L}^{-1}$), *myo*-inositol (100.0 $\text{g}\cdot\text{L}^{-1}$), NAA (0.005 $\text{mg}\cdot\text{L}^{-1}$), and sucrose (40.0 $\text{g}\cdot\text{L}^{-1}$). The pH was adjusted to 5.9 before autoclaving. After inoculations the culture was kept for 50 days under 25 ± 2 °C, 16-h photoperiod, and 19 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ radiation. CPPU performed better than BAP for cultivar M.111 and it had similar response for cultivar M.7 as bud and shoot multiplication and multiplication rate is concerned. The BAP increased the number of shoots with higher length and with no callus formation in the shoot base, contrary to CPPU. The most efficient concentrations were 4.7 and 5.5 μmol for CPPU and BAP, respectively.

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In Vitro Shoot Multiplication of Adult Black Walnut (*Juglans nigra* L.)

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During Apr. 1999, the lower branches of mature black walnut trees were removed and cut into sections 48 cm long and placed horizontally in plastic flats filled with perlite in a shaded polyethylene-covered greenhouse. Water was applied by drip emitters and care was taken to avoid overhead water contact with the stem sections. Within 2 months, elongating, green, leafy shoots were excised, brought into the laboratory, surface disinfested and placed in vitro onto agar-solidified Long and Preece (LP) medium with 0.3 μM thidiazuron (TDZ), 0.5 μM indolebutyric acid (IBA), and either 0.1, 1.0, or 10.0 μM benzyladenine (BA). Explants were transferred to fresh medium after 1, 3, and 5 days in vitro and every 2 weeks thereafter. After 3 months in vitro, callus was excised and explants were all placed on LP medium with 10 μM BA and 0.5 μM IBA for 4 weeks. They were then transferred to LP with 0.3 μM TDZ, 1.0 μM BA, and 0.5 μM IBA for 2 weeks. This 4–2-week alternation of media has continued for more than 6 months. After 4 months in vitro, shoot clusters were subdivided, and individual microshoots recultured. Of the original 260 explants, 30 survived and have been subdivided into 111 cultures. These explants have produced 132 axillary shoots that are also multiplying. Adult black walnut will acclimate and proliferate in vitro, but only with careful attention to detail and regular transfers to fresh medium.

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Growth and Nutrition of Chrysanthemum Microplants Inoculated with Arbuscular–Mycorrhizal Fungi

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Effects of inoculation with arbuscular endomycorrhizal fungi (*Acaulospora scrobiculata* and *Glomus mosseae*) on acclimatization and growth of chrysanthemum (*Dendrothema glandiflora* Tzevelev) plants, propagated in vitro, under different conditions of fertilization (0, 20, and 40 $\text{mg}\cdot\text{L}^{-1}$ of NPK) were studied. Mycorrhizal colonization did not influence surviving percentage of chrysanthemum plantlets during the acclimatization stage; however, we could colonize the developing roots and reduce the amount of inoculum needed and beneficial effects on plant growth were obtained during early stages of colonizing. Plant growth in greenhouse was regulated by synergism between the effect of endomycorrhizal fungus type and soil fertilization with N, P, and K. Effects of *A. scrobiculata* were observed as an increase in number of leaves, leaf area, stem diameter, root volume and fresh and dry weight of leaves, stem and root. The *G. mosseae* fungus improved N, P, Mg, and Zn content in leaves; P, K, Ca, Mg, and Zinc in stem and Ca content in root. On the other hand, *A. scrobiculata* only increased N content in leaves, stem and roots; P content in leaves and roots, and Ca content in stem. Percentage of mycorrhizal colonization on roots was affected by adding N, P, and K to soil. The highest values were obtained with fertilization doses of 20 $\text{mg}\cdot\text{L}^{-1}$. The number of spores of mycorrhizal fungi was increased by adding fertilizer to soil (40 $\text{mg}\cdot\text{L}^{-1}$ of NPK).

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Alstroemeria Plants Free of Alstroemeria Mosaic Potyvirus (AIMN) through in Vitro Culture Shoots and Thermoherapy

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Alstroemeria (*Alstroemeria* spp.) is cultivated for cut flowers. Traditional propagation methods are by division of rhizomes from mature plants, so that viruses occurring in the crop can be multiplied and cause a decrease in the quality and production. The objective of this work was to obtain *Alstroemeria* cv. Rosario plants free of Alstroemeria Mosaic Potyvirus (AIMV) by in vitro culture of shoots and thermoherapy. The best percentage of explants without contamination was obtained when adding the disinfectant PPM (1%) to the medium Murashige–Skoog (MS) while the best induction of buds was obtained when using explants of 1.5 cm. in length. In vitro multiplication of shoots was best in treatments with 2iP (isopentenyl adenine), BA (benzyladenine), and zeatin (4.4, 6.1, and 6.6 buds per explant, respectively). Rhizogenesis was observed in rhizomes growing in MS with 4.9 μM AIB (indole butyric acid) and 1.5 $\text{g}\cdot\text{L}^{-1}$ of sugar. Sixty-seven percent of plants growing in vitro did not react to AIMV antiserum and did not show particles and viral inclusions. Thermoherapy treatments of 45, 50, and 55 °C during different periods of time produced from 25% to 87.5% of plants that did not react to AIMV antiserum and did not show virus particles or cytoplasmic inclusions.

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Environmental Effect on Polyembryony of Two Citrus Rootstocks

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Polyembryony is an important characteristic for citrus that allows them to be propagated clonally through seed. Even when it is genetically controlled by a quantitative trait, the environment in which the seed is developed can affect it. The aims of this investigation were to evaluate polyembryony in two citrus rootstocks in two harvest cycles and embryo germination of polyembryonic seeds. Embryos of 300 seeds of *Citrus volkameriana* and *C. amblycarpa* were counted and measured in Summer–Fall and Winter 1998 and 1999, respectively; embryo of 50 seeds of both rootstocks were germinated in vitro. The number of embryos per seed was 1.9 and 1.6 in *C. volkameriana* and 4.7 and 5.7 in *C. amblycarpa*. In *C. volkameriana*, we observed 42% of monoembryonic seeds during summer–fall and 67% in winter, whereas in *C. amblycarpa* 5.0 and 4.1% were detected, respectively. Only embryos that were larger than 1 mm long germinated. Even when germination takes similar time (5 to 6 days), further growth is faster in larger embryos (5 to 10 mm) than smaller ones. Therefore, size of embryos would need to be considered for propagation purposes.

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Establishment and Multiplication of in Vitro *Pyrus* spp. Cultivars

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The culture of meristems, shoot tips, and axillary buds leads to the method of in vitro multiplication that is easily used and safe to obtain uniform copies with no undesirable variations. This work aimed to propagate five in vitro pear cultivars: Housui, Carrick, Nijisseiki, Packham's Triumph, and Red Bartlett. The work was carried out in the Tissue Culture Laboratory at Embrapa Temperate Climate. The plants were sprayed with benomyl (1.0 mg/L) and agrimycin (2.4 mg/L) in the fields, 2 weeks before the shoots were collected. The shoots were then cut with two buds with no leaves and disinfested with alcohol 70% for 10 s and 1% sodium hypochloride for 20 min, 50 explants, 25 buds, and 25 meristems, were then transferred to test tubes containing MS salts and vitamins, *myo*-inositol (100.0 mg/L), sucrose (30.0 g/L), agar (6.0 g/L), added to in mg/L : BAP (1.0), GA₃ (0.1), and NAA (0.01). Three pear cultivars were used for in vitro multiplication ('Nijisseiki', 'Red Bartlett', and 'Housui') by using the same basal salt with N reduced to strength, added to (in mg/L): BAP (1.6), NAA (0.16). The material was kept in growth room under 16-h photoperiod, 25 ± 2 °C and 19 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ of

flux radiation. The in vitro contaminations were mainly due to bacteria derived from the bud material (71.5%). Higher oxidation for meristem material was observed for 'Carrick' and 'Packham's Triumph'. 'Red Bartlett' showed the best results for all the variable studied, although all cultivars in general presented low response.

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Vermicompost Enhances Germination in Low-viability

Echinacea purpurea Seed

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Vermicompost or worm-worked wastes have been reported to enhance seedling germination and growth during plug production. The objective of this project was to examine the effects of vermicompost on germination of a herbaceous perennial having varying viability in coir-based container media. Seeds of *Echinacea purpurea* (Purple Coneflower) collected from field-grown plants in 1998 and 1999 were considered low- and medium-viability seeds, respectively. A third group of seeds was purchased from a major seed company and was considered to have high viability due to optimal storage conditions. "Ragdoll" germination tests resulted in the following viability ratings: low (1%), 1998; medium (67%), 1999; and high (79%), purchased seed. The three sources of seed were planted into coir-based media. Vermicompost was incorporated into the media at 10% by volume. The control media did not have vermicompost added. Twelve days after project initiation seeds sown into media containing vermicompost had 73% and 90% greater germination than control media for the 1999 and purchased seed. At the project conclusion, 24 days after initiation, seeds sown into media containing vermicompost had 23% and 42% greater germination than the controls for the 1999 and purchased seed. The 1998 seed had 5% germination after 24 days compared to 1% for the control. The addition of vermicompost could be used as a method to increase germination rate and percentage of seeds having lower viability.

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Micropropagation of Herbaceous Peony

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Micropropagation of herbaceous peony (*Paeonia*) cultivars and hybrids (Paula Fay, Cytherea, Prairie Moon, and Sarah Bernhardt) was investigated. Root clumps were removed from the field in February and forced in the greenhouse. Explants were excised buds from the crown area. Culture contamination levels were reduced by selection of crown buds prior to budbreak and disinfestation using combination treatments of 20 min with 5% potassium iodide followed by 10 min with 10% bleach. Genotypes responded differently to adventitious multiplication (Stage II) and tuberous root formation (Stage III) in Murashige and Skoog basal medium supplemented with 6-benzylaminopurine and gibberellic acid (Stage II) or indolebutyric acid (Stage III). Transfer to the greenhouse was accomplished (Stage IV) with a limited number of plants.

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Lupinus albus ssp. *graecus* L., A Native Plant with Potential for Floricultural Use

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Lupinus albus ssp. *graecus*, L. *Fabaceae* (Boiss. and Spruner) Franco and P. Silva, is being studied at the TEI of Heraklion since 1998 as a new plant with potential use in floriculture and ornamental horticulture. The plant has been recorded botanically; however, little is known about its physiology and genetic profile. *Lupinus albus* ssp. is a herbaceous annual plant 10 to 20 cm tall, growing at roadsides, field margins, vineyards, and olive groves up to 700 m altitude. The leaves are 5 to 11 cm wide, palmate shaped in alternate orientation, with five to nine leaflets 10 to 18 mm wide, all arising from the same point. The flowers are borne in terminal or lateral spike-like racemes 10 to 20 cm long. Florets are 15 mm long, dark blue occasionally with a white patch, stamens forming a tube. Pods are 60 to 70 mm long, with four to six black-spotted seeds. In the present work, seed germination studies were conducted combining chilling pretreatments with physical scarification (scratching). Mature seeds chilled at 5 °C for 6 weeks germinated readily (83%) when scarified with sand paper. Furthermore, we tested the effects of several plant growth regulators (chlorocholine chloride, paclobutrazol, maleic hydrazide and Ethrel 48) on young plants of *Lupinus* in order to obtain compact pot plants with more flowering racemes. Paclobutrazol at 5 and 10 mg/L achieved

the best retardation effect, but did not affect flowering. In another trial with different potting media, the commercial potting soil proved the most suitable for growing lupins satisfactorily. It is concluded that *Lupinus albus* ssp. *graecus* L. need further investigation in order to establish the best cultural conditions for its growth and development. Furthermore, due to its high genetic variability, selection and genetic improvement is required for optimal results.

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Conservation of an Endangered Virgin Islands Orchid Species through Tissue Culture

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The Sandy Point Orchid (*Psychilis macconelliae*) is listed as an endangered orchid species by the U.S. Virgin Islands Dept. of Planning and Natural Resources. This orchid grows naturally on the southern dry and wind-swept slopes found on the east-end of St. Croix. It can be found growing among cacti and bromeliads. Due to disturbance to the native habitat from land development, private collectors, and natural disasters, the population has diminished. Tissue culture is being successfully used in a conservation effort for this endangered species. Maturing seed pods were collected and surface disinfested and established in vitro. The medium consisted of one half Murashige & Skoog salts, Nitsch & Nitsch vitamins, 20 g/L sucrose, 2 g/L soy peptone, 5 g/L activated charcoal and 8 g/L agar. Seeds were spread on the medium in 15 x 100-mm petri plates and grown at 25 °C under a 16-h photoperiod. Seed germination occurred within 2 months with the development of protocorms. Leaves and roots developed by 5 months, at which time they were separated and transferred to fresh medium. At 8 months, they were established in a greenhouse and released back into their environment within 12 months. In vitro germination of the Sandy Point Orchid seed is an effective way of conserving this endangered species.

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In Vitro Propagation of the Ornamental Bromeliad, *Tillandsia eizii*

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Many bromeliad species indigenous to the rain forests of Central and South America are threatened because of over-collection and habitat destruction. Studies were conducted to develop propagation protocols for *Tillandsia eizii*, a rare ornamental bromeliad of ceremonial significance to the Highland Maya communities in Chiapas, Mexico. We anticipate using in vitro propagation for the conservation of this species with the potential of utilizing bromeliads as an alternative and sustainable forest resource. Protocols were developed for the sterilization and germination of axenic seed. Seedling growth in vitro was assessed and outplanting studies were conducted. Media were evaluated to promote adventitious bud production in experiments using the plant growth regulators naphthaleneacetic acid and benzylaminopurine. Pulse time and duration, as well as the stage of seed development, had a marked effect on bud production. The effects of various potting media on plant growth and survival were assessed. A pure pine bark medium elicited over 95 percent survival. Plants exhibited a "tank-like" morphology characteristic of plants in the wild.

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Vegetative Propagation of *Spigelia marilandica* (Indian Pinks) from Shoot-tip Cuttings

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Wild populations of *Spigelia marilandica*, a clump-forming perennial, are being destroyed because of its recent popularity and the plant is now becoming rare in its native habitat. The effect of the stock plant environment on the rooting capability of *Spigelia marilandica* cuttings is the primary focus of this research. Cuttings were obtained from greenhouse (GH) grown plants on a monthly basis, and from plants maintained in outside field beds (FB), season permitting. Cuttings were dipped in Hormodin 1 (1000 IBA), placed in a perlite:peat mix, and put under mist for 8 weeks. During the experiment, 91% rooting of cuttings obtained from GH-grown plants and 35% rooting of cuttings obtained from FB-maintained plants was observed. Cuttings from GH-grown plants averaging 39 roots/cutting (average FW/cutting = 1.243 g, average DW/cutting = 0.1574 g) were compared to

cuttings obtained from FB-maintained plants averaging 9 roots/cutting (average FW/cutting = 0.6041 g, average DW/cutting = 0.0663 g). A statistically significant difference was found between the two stock plant environments, with the cuttings from the GH-grown plants having an advantage over the cuttings obtained from the FB-maintained plants. A separate comparison was made of the cuttings obtained from the GH-grown plants over the 12 months of the experiment and the analysis showed no significant difference in the average FW/cutting, DW/cutting, and the number of roots/cutting.

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An In Vitro Regeneration System for Mass Production of Daylily (*Hemerocallis fulva* L.)

Johnny Carter* and Seema Dhir; Agricultural Research Station, Fort Valley State University, Fort Valley, GA 31030

A plant regeneration protocol has been successfully developed to mass propagate daylilies. Experiments were conducted to determine source (BA, KN, and ZT) and concentration (0, 1.0, 2.0, and 3.0 mg/L) of cytokinins and sugars (glucose, sucrose, and maltose) to be used in the medium. Studies were also conducted to determine the influence of flower bud size (5, 10, 15, and 20 mm) as explant source. Based on results from these studies a protocol for propagating daylilies was developed. The procedure involved using filament explants from daylily flower buds ranging in sizes from 5 to 10 mm. The filaments when cultured on MS+BAP (3.0 mg/L)+ IAA (0.5 mg/L) medium, formed globular somatic embryos in 4 weeks. Complete plants were regenerated within a period of 6 to 7 months. Upon acclimatization, 100% of the tissue culture generated raised plants survived under greenhouse conditions.

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Temperature and Gibberellin Acid on Seed Germination of *Iris versicolor* L.

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Iris versicolor (blue-flag iris) is a native aquatic plant that grows from Maine to Virginia. It is an important species of wetland regeneration and restoration. Unfortunately, seed germination seldom occurs in the wild. To address this problem, seeds of *Iris versicolor* were soaked with gibberellin acid (0, 500, 1000, and 1500 ppm) for 24 h after 120 days of cold treatment at 4 °C and then were randomly assigned to three germination temperatures (constant 21 °C; 24 °C/18 °C; 27C/15 °C) and placed in darkness. Germination rates for the three temperature treatments were 54.4% (21 °C), 96.5% (24 °C/18 °C), and 96.0% (27C/15 °C). Oscillating temperature treatments had significantly greater germination rate than constant temperature. Gibberellin acid had significant influence on germination rate; only the constant 21 °C was not favorable for germination. The germination rate was higher at 1000 than at 500 ppm or 1500 ppm or more. Germination occurred within 10 days under germination temperature treatments. All seedlings in petri dishes were successfully transplanted into growing flats.

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Propagation/Tissue Culture

Wednesday, 26 July, 1:00–2:00 p.m.

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Quantification of Reduced Sugars, Starch, and Total Soluble Carbohydrates in Potato Plantlets Cultivated In Vitro in Media with Different Sucrose Concentrations

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The aim of this work was to evaluate the effect of sucrose on the in vitro multiplication of potato, cultivars Baronesa, Macaca, and Cristal. The nutrient medium used was the MS basal salts and vitamins added to 100 mg·L⁻¹ myo-inositol. Four sucrose concentrations (20, 30, 40, and 50 g·L⁻¹) were tested. The pH was adjusted to 5.9 before autoclaving. Each treatment had 15 explants, which were collected from the lower part of the shoot containing two buds. This material was inoculated in a 250-mL flask with 40 mL of nutrient medium. After inocula-

tion the flasks were kept in a growth room under 25 ± 2 °C, 16-h photoperiod, and 19 μmol·m⁻²·s⁻¹ radiation provided by cool-white fluorescent lamps for 30 days. This trial was designed in a randomized block with three replicates. Every 7 days, the parameters were collected as follows: number of buds, shoot length and number of shoots. It was observed that 'Baronesa' presented the highest number of buds and rate of multiplication. 'Cristal' had a slightly better performance for these parameters. Plants treated with sucrose at 50 g·L⁻¹ led to a higher number of shoots. However, 'Macaca' treated with sucrose at 40 g·L⁻¹ had the highest shoot length.

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Hydroponic Minituber Production

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Minituber production was investigated using ex vitro 'Norland' plantlets in a rockwool-based hydroponic system. Productivity was evaluated for 12- and 16-h photoperiod pre-treatment, planting density (two, four, and six plantlets/ slab), vertical or horizontal orientation, pinching, and hilling. Total yield differences did not result from photoperiod pre-treatments, but 12-h pre-treatment increased the number of minitubers in the desirable 10- to 40-g size range. Increased planting density reduced yield per plant but caused small increases in yield per slab. Planting orientation, pinching, or hilling had no effect on overall fresh weight yield, number, or size distribution. Short photoperiod pre-treatment, and planting densities of four to six plantlets/slab, oriented vertically, are recommended.

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Manipulation of Microtuber Yield and Size Distribution in Successive Harvests

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The effect of successive harvests on potato microtuber yield (fresh weight and number) and size distribution in stationary liquid cultures was evaluated in cultivars Norland, Bintje, and Shepody. Harvesting microtubers successively at both 33 and 65 days, compared with a single harvest at 65 days, increased the total number of microtubers but decreased the number of larger microtubers (>0.75 g). Selective removal of Shepody microtubers >8 mm (>0.5 g) at 33 days increased the combined total number of microtubers from both harvests, but decreased the number of very large microtubers (>1.5 g). Successive harvest had no effect on total fresh weight yield, but increased overall microtuber numbers and skewed the size distribution downwards.

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Evaluation of Textile Fiber Residues for Horticultural Use

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Textile fiber residues spun into small (2 to 5 mm), soft pellets (Flocagro®), through a patented process, were evaluated for horticultural use. Pellets alone and in mixtures with other substrates, were assessed using standard criteria including cation exchange capacity (CEC), aeration porosity, bulk density, and water-holding capacity. The physical and chemical properties of these textile pellets were acceptable as a horticultural growing medium when mixed with substrates such as peat; it was light-weight, had a high water-holding capacity, moderately high aeration porosity, neutral pH, low inherent fertility, low buffering capacity, and mixed easily with other substrates. The potential of Flocagro® in potting mixtures for radish and tomato seedlings and micropropagated potato plantlets was demonstrated.

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Plant Regeneration via Organogenesis and Embryogenesis from Different Tissues of Sweetpotato

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The objective was to determine optimum conditions for embryogenic callus, embryo, organogenesis, and embryogenesis developed from leaf, petiole, stem, and tip tissues of the sweetpotato 'Jewel' cultivar and from subcultured callus. Embryogenic callus was developed from stem and tip tissues on MS medium

containing combinations of BA and NAA only under light conditions. Plant regeneration via organogenesis was developed from stem and tip tissues on medium including 1, 3 and 4 mg/L BA under dark and light conditions, while no plant regeneration via organogenesis was developed from leaf and petiole tissues. Frequencies for plant regeneration via organogenesis from the tissues were very low. No plant regeneration via embryogenesis was developed from the four tissues on medium having any combinations of BA+NAA and of kinetin+NAA. Embryogenic callus was observed in the subculture of callus developed from petiole and tip tissues on medium containing 0.2 and 2 mg/L 2,4-D only under dark conditions. Embryo was found in the subculture of callus from the tissues on medium containing 0.2 mg/L 2,4-D only under both conditions. Plant regeneration via embryogenesis was obtained in the subculture of callus from the tissues. Plant hormones and other factors affecting plant regeneration from the four tissues of the 'Jewel' cultivar and other elite cultivars are currently being investigated at our lab for its application in transformation.

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Effects of Explant Type, Sucrose Level and Callus Development Time on In Vitro Plant Regeneration of Sweetpotato

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Several experiments were conducted to evaluate the influence of explant type, sucrose level, and callus development time on sweetpotato [*Ipomoea batatas* (L.) Lam] in vitro culture. Shoot tip, petiole, and leaf of Selection 75-96-1 was used as explants in Murashige and Skoog (MS) media with different plant growth regulators. Calli derived from shoot tip and petiole produced 42.1% and 10.3% somatic embryos, respectively, but the leaf failed to produce somatic embryos. The effect of sucrose level was determined using shoot tip as explants. Compared with 3% sucrose in the same plant growth regulators level medium during callus initiation and callus proliferation periods, 5% sucrose level suppressed root growth and improved shoot regeneration. The callus development time was measured by using shoot tips on callus initiation medium containing 1.5 mg/L alpha-Naphthaleneacetic acid (NAA) and 0.25 mg/L Kinetin (KIN) plus 5% sucrose. When explants were cultured for less than 6 weeks during callus initiation, then transferred onto plant regeneration medium, plant regeneration via organogenesis occurred; whereas, maintaining cultures for more than 12 weeks on the same callus initiation/proliferation medium, plant regeneration was favored via embryogenesis. Explant type and other factors affecting plant regeneration noted here could be applied to protoplast culture, somatic hybridization, and transformation in sweetpotato.

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Enhancement of Microtuber Production in Temporary Immersion Bioreactors with Ancymidol

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Microtubers (*Solanum tuberosum* cv Snowden) were produced in 1-L jar fermentors using a two-step method consisting of a shoot multiplication phase (21 days) followed by a tuberization phase (25 days). The plantlets were immersed in Murashige and Skoog (MS) liquid medium for 3.5 min every 4 h. Low concentrations of ancymidol (anti-gibberellic substance), particularly during the shoot multiplication phase, were essential for tuber initiation and development. A continuous supply of 2 μmol ancymidol during the two phases of culture decreased plant height, but produced >100 microtubers per jar. Although the tuber development phase was short (25 d), 25% of the microtubers produced were >0.5 g with 17.5% to 18.0% of dry-matter content.

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Micropropagation of *Echinacea angustifolia*, *E. pallida*, and *E. purpurea* from Vegetative and Seed Explants

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Micropropagation of three *Echinacea* species, *E. angustifolia*, *E. pallida*, and *E. purpurea*, was investigated as a potential means of germplasm preservation of species faced with overcollection in the wild and rapid clonal propagation of elite individuals with unique medicinal or ornamental properties. Comparison of explant sources indicated vegetative explants resulted in high contamination rates when collected from shoot-tips (100%), but not when collected from nodal explants (11% to 39). Seed coat removal reduced contamination from 100% in intact seeds to near 0% in excised embryos. Removal of seed coats (pericarp and

integument layers) also eliminated dormancy requirement for germination. All species responded with shoot multiplication and loss of rooting when BA or thidiazuron was added to culture medium. Medium with thidiazuron resulted in excessive adventitious shoot formation. Shoot multiplication rates were low (one to three shoots/explant) on medium with BA levels low enough to avoid adventitious shoot formation. Medium containing half-strength MS minerals resulted in more shoots with smaller leaves than full-strength MS minerals. Cultures did not perform well on Woody Plant Medium. Increasing subculture frequency from every 4 weeks to every 2 weeks increased shoot multiplication rates from 1.4 to 1.8 shoots per subculture and total shoots produced after 12 weeks of culturing (per initial explant) from 2.8 to 23.9. Rooting occurred readily on shoots isolated from *E. purpurea* without addition of IBA. Rooting was low or non-existent on shoots from *E. angustifolia* and *E. pallida*, respectively, regardless of IBA level, light conditions, or temperature. Methods described in this study allow rapid multiplication of three *Echinacea* species and subsequent rooting of *E. angustifolia* and *E. purpurea*. Future improvements in root induction treatments will allow more effective use of micropropagation for *Echinacea* germplasm preservation and multiplication. Chemical names used: *N*-(phenylmethyl)-1*H*-purine-6-amine (BA), 1*H*-indole-3-butyric acid (IBA).

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Meristem Isolation of Garlic (*Allium sativum* L.) Cultivars Sao Marcos and Sao Valentim

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Garlic (*Allium sativum* L.) belongs to the Alliaceae family and originated from Asia and Mediterranean countries. Their bulblets are rich in starch and aromatic substances. The rate of garlic propagation in field conditions takes several years for the production of a certain number of seed bulbs for the release of a new variety. The use of tissue culture techniques is a useful tool for overcoming this problem. The aim of this work was to increase the mean number of shoots derived from the meristem isolation and to verify the percentage of callus formation and to analyze vigor of the material. The initial meristems were inoculated in a salt and vitamin B5 media except for the iron element, which was provided by MS medium added to in mg·L⁻¹: myo-inositol (100.0), nicotinic acid (1.0), piridoxine (1.0), thiamine (10.0), sucrose (20.0 g·L⁻¹), agar (6.0 g·L⁻¹). BAP and TDZ were added at: 0.0; 1.0; 1.5; 2.0; and 2.5 μM . This material remained in a growth room for a 16-h photoperiod, radiation of 20 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ and 25 °C for 40 days. Although 'Sao Marcos' produced more vigorous shoots, no significant difference was found for the mean number of shoots. 'Sao Valentim' cultivar shows more callus at the shoot base, making this cultivar more prone to somaclonal variation. On the other hand, BAP stimulates the appearance of callus, but it has been shown that this is cultivar-dependent.

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Light Exposure and Gibberellic Acid Effects on Common Carpetgrass (*Axonopus affinis* Chase) and Centipedegrass

[*Eremochloa ophiuroides* (Munro) Hack.] Seed Germination

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A study to determine the influence of light duration on seed germination was performed in a temperature-controlled growth chamber. Light treatments consisted of 0 (control), 6, 8, 10, 12 and 14 h of light exposure. Cool fluorescent light bulbs provided 19 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ light. Fifty seeds of each treatment were placed into separately labeled 6.0-cm-diameter petri dishes lined with Whatman #42 filter papers moistened with 2 mL of distilled water. Seed of both species germinated poorly in the control treatment. Mean time of germination (MTG) and germination percentage increased for both species when seeds were exposed to light. Pre-soaking seed in gibberellic acid (GA) significantly improved germination percentages of both species compared to the untreated control. Centipedegrass germination percentage and MTG also increased with light exposure. Carpetgrass seed germination was not enhanced by GA treatments with light exposure. The results of this experiment suggests that, if seed are covered too deeply, excluding light, MTG and percentage germination will be reduced. However, pre-soaking seed in a GA solution can improve dark germination by as much as 50% for both grass species.

A Comparison of Virus-free Versus Infected Sweetpotato Transplants for Cutting Propagation

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Production of disease-free sweetpotato [*Ipomoea batatas* (L.) Lam.] transplants is of major importance to certified and foundation seed programs and producers. Sweetpotato roots are traditionally planted and cuttings are harvested from propagation beds. The objective of this study was to investigate the efficiency of producing cuttings in nursery containers. Virus-tested and virus-infected 'Beauregard' sweetpotato transplants were harvested from planting beds for the purpose of producing cuttings for transplants. Cuttings were established in 3.7-L plastic nursery containers filled with 100% pine bark amended with either low, medium, or high rates of Osmocote 14-14-14 and dolomitic lime. Resulting transplants produced a greater number of cuttings and greater plant biomass with higher fertilizer rates. Increasing fertilizer rates also had a positive effect on cutting production and biomass. Dry weight and stem growth were similar for both virus-infected and virus-tested transplants following first and second harvests. Producing foundation cuttings in nursery containers filled with a pine bark medium proved to be an efficient method of increasing virus-tested sweetpotato cuttings.

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The Effects of Plant Growth Regulators, AgNO₃, Dark Treatment, and Antibiotics on Shoot Induction from Cotyledon and Hypocotyl of Chinese Cabbage

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The development of genetic transformation systems has led to remarkable progress in the area of plant molecular biology. This has included the introduction of useful traits, such as resistance to viruses, herbicides, and insects. Transformed plant cells can be selected, using chimeric genes that confer resistance to toxic drugs, such as kanamycin, hygromycin, streptomycin, gentamycin, and bleomycin. Expression of these chimeric genes in the transformed cells confers the ability to survive and proliferate on the selective medium, while non-transformed cells die. In this study, we report a simple and efficient system to regenerate Chinese cabbage plants and study the effects of plant growth regulators, AgNO₃, initial dark treatment, various antibiotics, and herbicide on shoot induction from hypocotyl or cotyledon of Chinese cabbage. Shoots were induced at various combinations of naphthalene acetic acid (NAA) and benzyladenine (BA) levels. The best combination of plant growth regulators was 2.0 mg/L NAA and 1.0 mg/L BA for cotyledon, and 1.0 mg/L NAA and 5.0 mg/L BA for hypocotyl. The experiment investigating the effect of AgNO₃ demonstrated that 16.7 mg/L AgNO₃ was effective for inducing shoot regeneration from both of explants. Three to five days of initial dark treatments had significant effects for increasing the number of regenerated shoots; however, different growth regulator combinations showed various responses to duration of dark treatments. The effects of kanamycin, hygromycin, cefatoxime, carbenicillin and phosphinothricin (PPT) on shoot induction from cotyledon and hypocotyl were tested. Shoot induction was completely inhibited by kanamycin at 10 mg/L, hygromycin at 5 mg/L, PPT at 5 mg/L or higher, but not by carbenicillin and cefatoxime.

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CO₂-Ultrasonic Fogging System Enhances Tissue Culture Shoot Survival and Growth

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An inexpensive ultrasonic fogging system is presented that aids in the establishment of tissue culture shoots in soil under greenhouse conditions. In addition, ultrasonic fogging may be coupled to CO₂ nutrient enhancement via bubbling CO₂ into the water reservoirs prior to fogging to improve growth and morphogenesis responses of shoots. A list and cost of items for the system and its assembly is given. Transplanted tissue culture shoots of basil (*Ocimum basilicum* L.), hosta (*Hosta* sp.), mint (*Mentha* sp.), and thyme (*Thymus vulgaris* L.) were tested with this fogging system with and without CO₂ nutrient elevation and compared to the growth of shoots grown under a misting system with and without CO₂ nutrient elevation. In all cases, ultrasonic fogging enhanced survival rates, growth (fresh weights) and morphogenesis (axially shoots, leaves and roots) vs.

that occurring in the misting system. For example, thyme and mint shoots exhibited 2- and 5-fold increases, respectively, in fresh weights under ultrasonic fogging with CO₂ compared to misting systems with CO₂. Associated with enhanced survival and morphogenesis was an overall enhancement of shoot and leaf size and overall maturation responses. This is also reflected in enhanced secondary products obtained from shoots grown under ultrasonic fogging compared to shoots grown in misting systems.

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Chlorophyll Content is Negatively Correlated with Muskmelon Seed Quality

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Maturity at harvest determines seed viability and vigor. However, separating seeds from different stages of development can be difficult using existing seed sorting technologies. New technology non-destructively sorts seeds based on their chlorophyll fluorescence (CF), so seeds with the same dry weight but with different physiological maturates can be separated. We determined whether chlorophyll content of muskmelon (*Cucumis melo* L. cv. Top Mark) seeds changes during development and whether those changes were related to viability and vigor. Seed viability and vigor were determined using an Association of Official Seed Analysts wet paper towel germination test. 'Top Mark' seeds from nine stages of development were run through the SeedMaster Analyzer (Satake USA Inc., Houston, Texas), which calculated the chlorophyll content of each seed. The CF signal was fed into a computer to obtain a frequency histogram. Forty, 45, and 55 days after anthesis (DAA) seeds had germination percentages of 96%, 98%, and 100%, respectively, the highest in the study. Fifty-five DAA had greater seed vigor and viability and contained the lowest CF values; 207 on the 1000-value scale. The less-mature seeds contained higher chlorophyll content and had the lowest seed vigor and viability. Seed vigor and chlorophyll content were negatively correlated in this study. All seeds with high CF values had low vigor, but not all seeds with low CF values have high vigor. Seed aging during storage can reduce viability and vigor independent of chlorophyll content. Based on chlorophyll content, the SeedMaster Analyzer can non-destructively remove immature, low-vigor seeds that have the same physical characteristics and weight as more mature seeds. Chlorophyll fluorescence technology may allow the seed industry to further improve seed quality and maximize vigor.

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The Plant Tissue Culture Information Exchange Media Database

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The Univ. of Minnesota hosts the PLANT-TC Listserv as a service to the international tissue culture community (<http://www.agro.agri.umn.edu/plant-tc/listserv/>). One of the most frequently sought types of information is a recommendation for a "beginning point" for culturing a wide variety of plant species. Many of these inquiries come from individuals without ready access to extensive library holdings, including those in industry, public schools, and international sites. A Web site prototype that includes a searchable database of tissue culture recipes is being constructed and offered for user input. The database currently is located at <http://webtutor.tamu.edu/students/herring/project/>, but will be redirected to its own URL if user feedback is positive. The database also includes information about equipment and materials, media suppliers and domestic and foreign sources for tissue cultures and micropropagated plants. Other educational resources, including a virtual tour of a commercial tissue culture lab, are available on the site. The Web site and database will be reviewed by a panel of experts and modified according to their input prior to being posted for public access.

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Overcoming Seed Dormancy in Winecups, *Callirhoe involucrata*

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Propagation of Winecups [*Callirhoe involucrata* (Torrey & A. Gray)] for use as a landscape ornamental has been impeded by a lack of understanding of the seed dormancy and a practical method for overcoming it. As with many members of the Malvaceae family, *C. involucrata* produces hard seed. In the populations