

Abstracts

Contributed Papers (Poster and Oral)

Workshops

Colloquia

ACB Orals

ACB Posters

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The Abstracts that follow are arranged by type of session (Posters first, then Orals, Colloquia, and Workshops). The Poster abstract numbers correspond to the Poster Board number at which the Poster will be presented.

To determine when a paper is to be presented, check the session number in the Program Schedule or the Conference at a Glance charts. The Author presenting the paper is indicated by an asterisk.

42 POSTER SESSION 1A (Abstr. 001–014) Culture & Management/Nutrition— Vegetable Crops

001

Growth Analysis and Performance of Four Sweetpotato Cultivars Under Different Levels of Nitrogen and Potassium

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The objectives of this work were: Establish the growth pattern of four cultivars and evaluate different cultivar performance at different rates of fertilization. 'Morada Inta', 'Kokey 14', 'Sandu', and 'Lago' were transplanted in Nov. 1995 and were grown at 0, 50, and 100 kg/ha of nitrogen and 0 and 100 g/ha of potassium. Sequential samples were done throughout the growth cycle. The parameters evaluated were: Fresh and dry weight of leaves, stems and roots, stem length, internode distance, and leaf area. A color foliage evaluation was complemented by foliar analysis throughout the growth cycle. At the end of the crop cycle, nitrogen and potassium content and soluble solid levels at the roots were determined. Cultivars differed most for all the parameters evaluated. Fertilization affected stem length, internode distance, foliar and root N, color determination, and soluble solid content. Plant, stem, root dry weight, leaf area, and yield tended to be greater at 100–0 kg/ha of N–K rate.

002

Effect of Nitrogen Fertilization on Yield and Quality of Some Salad Crops

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The present experiments were carried out at the Assiut Univ. Experimental Farm during two winter seasons, 1994/1995 and 1995/1996, to study the effect of nitrogen source and level on growth, yield, and quality of salad crops (lettuce, parsley, and roquette). Nitrogen sources were urea, ammonium nitrate, and ammonium sulfate. Three nitrogen levels, namely 20, 40, and 80 kg N/feddan, in addition to organic manure (2.028% N), in addition to the control, were used. Plant height, number of leaves (parsley and roquette), number of non-edible leaves (in lettuce) were significantly increased with urea followed by ammonium nitrate. Plant fresh weight, weight of edible part (in lettuce), and total yield/feddan were significantly higher with urea than ammonium nitrate or ammonium sulfate. The lowest content of nitrate and nitrite in leaves of the salad crops was obtained with ammonium sulfate followed by ammonium nitrate, while urea gave the highest values. Application of organic manure produced plant height, number of leaves per plant, plant fresh weight, total yield, dry matter content almost equal to that obtained from 40 or 20 kg N/fed. Nitrate and nitrite content were at their lowest value when organic manure was used. Plant height, number of leaves, non-edible leaves, weight of plant and total yield/feddan were significantly increased with increasing nitrogen rates from 0 to 80 kg/feddan. Using 80 kg N/fed. gave the highest dry matter, nitrate, and nitrite content.

003

Nitrogen Applications Alter Tissue and Soil N Levels but Not Postharvest Quality of Boston Lettuce Grown on Ohio Muck Soils

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Unreplicated nitrogen rate demonstrations in 1996 indicated that nitrogen fertilizer rates may reduce storage life and postharvest quality of Boston lettuce grown on Linwood muck. A field trial using three planting dates, four nitrogen rates, and six replications was conducted using Boston lettuce cv. Esmirelda. All nitrogen, phosphorus, and potassium was broadcast and disked-in prior to planting. The spring planting used greenhouse-grown plugs. The summer and late summer sowings were direct-seeded. Soil and plant tissue tests were taken and correlated with fertilizer N rate and yield. In the spring planting, each plot was harvested at maturity, rather than all at once. Twenty-four trimmed heads were boxed, hydrocooled, and stored in a commercial cold storage room at 0 to 1 °C. The boxes of lettuce were weighed before and after cooling, and every 24 to 48 h thereafter, until all boxes were deemed not salable. Samples were rated for soft rot symptoms after the final weighing. The spring planting was the only one to show significant differences in days to crop maturity among nitrogen rates. No differences in head weight, weight loss during storage, or number of heads with rot symptoms were found in the mid- or late summer crops. Wrapper leaf nitrate levels at harvest increased with applied nitrogen rate. Residual soil nitrate increased with applied nitrogen in the late summer trial.

004

Effect of Nitrogen Application Rates on the Yield of Head Cabbage, Japanese Eggplant, and Two Distinct Tomato Cultivars in Hawaii

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Little nutrient calibration data exists for the production of vegetables in the tropics. Replicated experiments were conducted to evaluate the effect of several N application rates on the yield of head cabbage, Japanese eggplant, an old open-pollinated determinate tomato cultivar, and of 'Merced', a standard commercially grown determinate tomato hybrid. Data collected included soil nutrient analysis prior to experiment initiation, tissue nutrient analysis, nutrient sap analysis for eggplant, canopy dimensions for eggplant and tomato, and marketable yields. Additional data collected in tomato included both laboratory tissue nutrient analysis and NO₃ and K⁺ determinations, through rapid sap analysis kits, collected during three crop growth stages, ripened fruit soluble solid determinations, and NO₃ determinations at three soil depths conducted ≈2 weeks after the last harvest. Yields of head cabbage, grown at about 360 m elevation, were not affected by

N application rates ranging from 0 to 300 kg N/ha. Eggplant was grown at sea level in a soil rich in organic matter. Eggplant yields from an 8-month harvest period were little affected by N rates ranging from 0 to 300 kg·ha⁻¹, except for a trend toward greater yields with the highest N rates, during the last 4 months. In tomato, the old OP variety was less responsive to N than the newer tomato hybrid. Greatest 'Merced' tomato yields were obtained with 100 to 200 kg N/ha in treatments ranging from 0 to 400 kg N/ha. Our data indicate that acceptable yields are obtained with modest N application rates, and that excessive N applications by commercial growers may result in nitrate leaching, and in unnecessary fertilizer application expenses.

005

Influence of Nitrogen and Potassium Fertilization on Yield and Quality of Carrot

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The influences of various nitrogen and potassium fertilizer levels on the growth, yield, sugar content, and tissue mineral concentrations of carrot (*Daucus carota*) were investigated. Nitrogen (0.0, 7.3, 14.7, 22.0, 29.4, 36.7 kg/ha) and potassium (0, 4.6, 9.2, 18.4, 27.5, 36.7 kg/ha) were applied to the sandy loam soil prior to seed planting. Plants were grown without irrigation. The total root yield was the highest (68.2 t/ha) at a nitrogen level of 29.4 kg/ha. Potassium did not affect either the total root yield or the number of marketable roots. Root sugar contents were slightly higher when plants were grown with potassium levels at 18.4 kg/ha or higher as compared to lower K application rates. Root sugar contents were unaffected by nitrogen levels. The relationships between the leaf petiole sap nitrogen and potassium concentrations and the shoot dry mass concentrations of N, K, and other minerals were determined.

006

Evaluation of Nitrogen Sources and Rates on the Yield and Quality of Sweet Onion

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During the 1980s, research was conducted mainly for long-day onion, with limited research on cultural practices for short-day cultivars, in Uruguay. Sweet onion production became important in Uruguay in 1992. Research was conducted on cultivar adaptation, sowing time, plant population, transplanting and direct-seeded methods, irrigation, and plant protection. Onion fertilization criteria were established for long-day cultivars in the southern region in the 1980s. National Research Inst. of Agriculture started a study on sweet onion fertilization using four N rates, 0, 60, 120, and 180 kg/ha, and four N sources, urea, ammonium nitrate, potassium nitrate, and calcium nitrate. Nitrogen was applied into the soil 40% before transplanting and the remaining 60% in two applications in the spring. Granex 33 cultivar was transplanted on 27 June 1997 into a soil with the following characteristics, pH 6.4, P (Bray 1) 44.5 ppm, organic matter 3.3, and K 0.64 meq/100 g. Beds were separated 1.5 t, with four rows and plants 12 cm apart. Plant height and leaf color were evaluated. Lack of nitrogen and 60 kg N/ha showed lighter green colored leaves. Leaf, total plant, and soil samples were collected to determine nutrient status and dry matter production. Bulbing ratio was measured in 10 plants in each plot. Sweet onion quality was done by pyruvic acid analysis.

007

Iron Deficiency Chlorosis and Seed Yield in Dry Edible Beans Grown on High-pH Calcareous Soils

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Iron deficiency chlorosis (FeDC) can cause significant seed yield reduction in dry beans (*Phaseolus vulgaris* L.) grown on high-pH calcareous soils. To determine the effects of FeDC on seed yield, and the effect of Fe-spray as a correction factor for FeDC, 22 breeding lines/cultivars were planted on high-pH (8.0), calcareous (3.2–3.5 calcium carbonate equivalent), and low-Fe (1.8–4.2 ppm DTPA) sandy clay loam Tripp soils at Mitchell and Scottsbluff in western Nebraska. A split-plot design was used with Fe treatments as main plots and breeding lines/cultivars as subplots. Three foliar sprays of Fe-EDDHA (2.4 kg·ha⁻¹) were applied at V4, R5, and R7 dry bean growth stages, during 1996 and 1997. Leaf chlorosis was measured simultaneously by using a Minolta Chroma-meter (CIE L* a* b* color

space system), a Minolta Chlorophyll-meter (chlorophyll content index), and by visual ratings (1 = normal green to 5 = severe chlorosis). In 1996 no significant Fe-spray x line interaction ($P = 0.776$) and Fe-spray effect ($P = 0.884$) on seed yield was observed. Breeding lines showed significant differences in seed yield ($P = 0.0001$) with WM2-96-5 being the highest-yielding line ($4047 \text{ kg}\cdot\text{ha}^{-1}$). In 1997 a significant Fe spray x line interaction ($P = 0.029$) was observed. The cultivar Chase without Fe spray ($3375 \text{ kg}\cdot\text{ha}^{-1}$), and lines WM2-96-5 ($3281 \text{ kg}\cdot\text{ha}^{-1}$), WM2-96-8 ($3171 \text{ kg}\cdot\text{ha}^{-1}$) with Fe spray were the highest yielding entries under those treatments. Differences in visual ratings after the third Fe spray in 1997 were significant ($P = 0.004$) for Fe spray x line interaction. In 1996 visual ratings were different only for breeding lines. Chlorophyll content index showed a significant Fe spray x line interaction after the second Fe spray ($P = 0.022$) and after the third Fe spray ($P = 0.0003$) in 1997.

008

Effects of Calcium Fertilizers on Pod Calcium Concentration and Yield of Four Snap Bean (*Phaseolus vulgaris* L.) Cultivars

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Four snap bean cultivars were grown during the summers of 1996 and 1997 in Hancock, Wis. Fertilizer treatments consisted on 80 kg of Ca/ha applied as gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) or calcium nitrate [$\text{Ca}(\text{NO}_3)_2$], and the control (no calcium applied). The experimental design was a randomized complete block with a factorial set of treatments (4 x 3) repeated six times each year. Gypsum was all applied at planting, whereas calcium nitrate was applied weekly starting 1 week prior to flowering for 4 weeks. Yield and calcium concentrations in pods were determined. The statistical analyses showed no significant effect from fertilizer type on pod calcium concentration or yield. A strong cultivar effect was detected for both parameters measured. 'Evergreen' (5.47 mg Ca/g dry wt) presented the highest pod calcium concentration and 'Labrador' (4.10 mg Ca/g dry wt) the lowest. No significant fertilizer x cultivar interactions were observed. Results for pod calcium concentration remained consistent, even when a significant year effect was found for both parameters. The results suggest that breeding and selection remain the most attainable methods to enhance pod calcium concentration in snap bean.

009

Zinc, Manganese, and Iron Fertilization in 'Spineless Beauty' Zucchini (*Cucurbita* sp.)

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Zucchini (*Cucurbita* sp.) fruit yield response to zinc (Zn), manganese (Mn), and iron (Fe) foliar fertilization was determined in field trials conducted in a loamy clay soil in Nigua, San Cristobal, Dominican Republic. The soil had Zn, Mn, and Fe contents of 1.2, 8, and 2 parts per million (ppm), respectively. 'Spineless Beauty' zucchini was direct-seeded at a distance of 1 m between rows and 0.5 m within rows. Except for Zn, Mn, and Fe fertilization, the crop was grown according to recommended practices. Experimental units contained five plants. A randomized complete-block design with a factorial arrangement (3 x 3 x 3) with four replications was utilized. Micronutrient rates were 0, 1, and 3 kg·ha⁻¹ for Zn; 0, 3, and 6 kg·ha⁻¹ for Mn; and 0, 3, and 6 kg·ha⁻¹ for Fe. Total rates were divided in two 50% rate applications, sprayed in aqueous solution to the crop leaves 15 and 30 days after emergence. Fruit harvest began 40 days after crop emergence and was performed every other day during 20 days. Resulting data was subjected to analysis of variance. There were significant Zn, Mn, and Fe interactions, and thus micronutrient combinations were considered as individual treatments. Treatment means were separated with the LSD 5% test. Zucchini plants treated with a combination of 3 kg Zn/ha, 3 kg Mn/ha, and 3 kg Fe/ha produced fruit yields 31.5% higher than control plants. Combinations including higher Mn and Fe rates failed to further increase zucchini yields.

010

Effect of Boron and Molybdenum Fertilization on 'Spineless Beauty' Zucchini (*Cucurbita* sp.)

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The effect of boron (B) and molybdenum (Mo) foliar fertilization on 'Spineless Beauty' zucchini (*Cucurbita* sp.) fruit yield was studied in Nigua, San Cristobal, Dominican Republic. Field trials were conducted in a loamy clay soil containing

0.3 parts per million (ppm) of B and no detectable amounts of Mo (detection limit 0.1 ppm). Zucchini was direct-seeded at a distance of 1 m between rows and 0.5 m within rows. Fertilization (except B and Mo applications) and other production practices were implemented as recommended. A randomized complete-block design with a factorial arrangement (0, 1, 2, and 3 kg B and 0, 0.1, and 0.2 kg Mo/ha) with four replications was utilized. Experimental units consisted of five plants. Fruits were harvested every other day during 20 days, starting 40 days after crop emergence. Yield data was submitted to analysis of variance. Significant B and Mo rate interactions were found. Maximum zucchini yields were achieved when the combination of 1.5 kg B and 0.1 kg Mo/ha was applied. Combinations containing 3 kg B/ha were toxic to zucchini, reducing yields in nearly 20% as compared to untreated plants.

011

Response of 'Spineless Beauty' Zucchini (*Cucurbita* sp.) to Nitrogen, Phosphorus, and Potassium Fertilization

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Field trials were conducted in Nigua, San Cristobal, Dominican Republic, to determine the yield response of 'Spineless Beauty' zucchini (*Cucurbita* sp.) to nitrogen (N), phosphorus (P), and potassium (K) soil applications in a loamy clay soil containing 4.3% organic matter, 3 parts per million (ppm) of P, and 155 ppm of K. Zucchini was direct-seeded at a distance of 1 m between rows and 0.5 m within rows. Except for N, P, and K fertilization, the crop was grown according to recommended practices. A factorial design (4 x 4 x 4) with four replications was utilized. Rates of N, P, and K were 50, 100, 150, and 200 kg·ha⁻¹, applied as a side dressing 7 days after zucchini emergence. Zucchini fruit harvest started 40 days after crop emergence and every other day thereafter during 20 days. Analysis of variance was performed on the resulting data. Results indicate that there were significant interactions of N, P, and K fertilizer rates on 'Spineless Beauty' fruit yield; therefore, nutrient combinations were considered as individual treatments. Significantly superior (LSD 5%) fruit yield was obtained with 150, 150, and 50 kg·ha⁻¹ N, P, and K, respectively.

012

Field Evaluations of Nutrient Absorption Enhancer and Starter Fertilizer in Bell Pepper

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In recent years, vegetable growers in the Midwestern United States have received much advertising information about using the synthetic protein polyaspartic acid (PA) in their fertility management program as a nutrient absorption enhancer. Supposedly, each long-chain PA molecule acts as an extension of the plant's root hairs; and by virtue of its negative charge, attracts nutrients to the root surface. The result should be a higher level of nutrient uptake, and correspondingly improved plant growth and crop yields. Subsequently, research was conducted at two locations, Urbana and St. Charles, Ill., evaluating various combinations of PA and starter fertilizer in bell peppers. At each site, PA at 0.24 ml/plant banded (5 x 5 cm) in combination with starter fertilizer (114N–240P–160K mg/plant) had a positive effect on plant growth, increasing shoot dry mass 8% and 11%, respectively, compared to starter fertilizer alone. There was a positive yield response to PA at St. Charles, but not at Urbana. At St. Charles, fruit production increased 14%, while yields increased 9% by applying PA as a greenhouse transplant soak (16.4 ml PA/2.0 L water per 512 plants in five applications) in conjunction with banded (5 x 5 cm) starter fertilizer (114N–240P–160K mg/plant). Tissue analysis at both locations showed various degrees of nutrient absorption enhancement. However, the physiological basis for PA-induced increases in plant growth and crop yields are not clear.

013

Soil Cation Balance Affects Tomato Fruit Color Disorders

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A survey of 140 processing tomato fields throughout central California was conducted in 1996–97 to determine whether soil factors affect the occurrence of the tomato (*Lycopersicon esculentum* Mill.) fruit color disorders "yellow eye" (a halo of yellow tissue around the stem scar) and white core (an abnormal amount

of internal white tissue); these disorders render fruit unsuitable for use as peeled or diced product. All fields were planted in 'Halley' or 'Heinz 8892'. Soil samples (0–30 cm) were analyzed for pH, texture, TKN, bicarbonate extractable P, and ammonium acetate-extractable K, Ca, and Mg. Ripe fruit were rated for the incidence (%) of fruit affected by one or both of the disorders, blended color, and % soluble solids (SS). Soil K (in meq., expressed as a % of base exchange) was negatively correlated with the incidence of the disorders, while soil Mg was positively correlated. Fields with extractable K <2% of base exchange averaged 21% of fruits affected by one or both disorders, compared to only 4% of fruits affected in fields with K >2.5% of base exchange and a Mg/K ratio (meq. basis) <12. Percent SS was weakly correlated with extractable K, but blended color was unrelated to any soil factor. In 1997 field trials, both gypsum application (to displace soil Mg) and K fertilization significantly suppressed the color disorders but did not affect yield, blended color, or % SS.

014

Canola Seed Glucosinolate Content as Affected by Boron Availability Under Water Stress

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It is hypothesized that soil boron (B) availability is influenced by water stress and affects canola glucosinolate content. This research was conducted to determine if added B can overcome water stress-induced changes in seed glucosinolate content in canola. The cultivars Cyclone and American A112 were grown in a continuously recirculating hydroponic system with modified Hoagland solutions. The experimental design was a randomized incomplete block. Two B concentrations and one water stress treatment (maintained with polyethylene glycol 8000, PEG) were used: 0.04 mg·L⁻¹ B (not water stressed, without PEG), 0.04 mg·L⁻¹ B (water stressed, with PEG), and 0.60 mg·L⁻¹ B (water stressed, with PEG). Osmotic potential was maintained at -0.1 MPa (with PEG) or 0.05 MPa (without PEG). The 0.04-mg·L⁻¹ B treatment without PEG had significantly lower total glucosinolates than the 0.04-mg·L⁻¹ B treatment with PEG. This indicates that at low available B levels, glucosinolate content is increased by water stress. The 0.04-mg·L⁻¹ B treatment with PEG had significantly higher total glucosinolates than the 0.60-mg·L⁻¹ B treatment with PEG. Thus, under water stress, the higher available B treatment resulted in lower seed glucosinolate content.

42 POSTER SESSION 1B (Abstr. 015–027) Floriculture/Greenhouse Management— Light/Temperature/Growth Regulators

015

Effect of Irradiance on *Hibiscus* L. Species Flowering

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The effect of supplemental lighting on flowering of six *Hibiscus* L. species was examined. Plants were grown in a greenhouse at 20 ± 1 °C under either of two photoperiods, 9-h (covered with opaque cloth from 1430–0730 HR) or 16 h. Within each photoperiod, four levels of supplemental light were provided using high-pressure sodium lamps. Total supplemental irradiance levels were: 0, 2, 4, and 8 mol/day photosynthetically active radiation (PAR), at the apical meristem, for plants grown under a 9-h photoperiod, and 2, 4, 8, and 16 mol/day PAR for plants grown under a 16-h photoperiod. Irradiance levels were measured weekly, with plants being moved to maintain the designated irradiance level at the apical meristem. Data collected included anthesis date, number of leaves below the first flower, lateral shoot and flower bud number, plant height, and flower diameter. Increasing daily light integral reduced the number of leaves below the first flower for some species in one or both photoperiods. Irradiance and photoperiod effects on lateral shoot and flower bud number at anthesis will be discussed. Photosynthetic-response curves and light-response curves with respect to flowering were constructed for each species. Response curve variation between species will be discussed.

016

Light Quality Regulation of Gene Expression in *Chrysanthemum*

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A major part of Clemson light quality research program focuses on understanding the mechanisms of plant growth alteration under spectral filters. We have extended this research to understand the molecular basis for plant height control by spectral filters. From the whole plant research we have found that gibberellins (GA) play a key role in height control under spectral filters. However, it is not clear whether an alteration of endogenous gibberellin levels or a change in sensitivity to gibberellins is causing the observed effects. Since gibberellins are a key hormone in cell expansion and flower development, an understanding of gibberellin regulation and metabolism under spectral filters is critical for the control of height and flowering of plants grown under these filters. For the molecular study, we have selected the gene that code for enzyme GA 20-oxidase, one of the key enzymes involved in producing functional GAs in the mevalonic acid pathway. GA 20-oxidase is thought to be a site of regulation of GA synthesis by the environment. We are currently studying the regulation of the expression of this gene by light quality using Northern analysis. Results from temporal and tissue specific regulation of chrysanthemum plants grown under CuSO₄ filters will be presented.

017

Effect of Irradiance Level and Paclobutrazol on Reduction of Leaf Damage in *Begonia x cheimantha*

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Begonia x cheimantha (Christmas or Lorraine begonia) is a popular holiday crop in Europe, with certain cultivars having outstanding postharvest characteristics. Its commercial production in the southern United States has been limited by the occurrence of mottled leaf chlorosis and necrosis, apparently due to environmental stress. In this study, *B. x cheimantha* 'Emma' was grown in the fall in a glass greenhouse at College Station, Texas, under either 0%, 60%, or 87% polyethylene shade cloth. Leaf chlorosis and necrosis was very severe on plants grown in full sun (≈650 mol·m⁻²·s⁻¹), with slight chlorosis on plants under 60% shade. Plants under full sun, however, were more compact, flowered earlier, and had shorter peduncles with more flowers than those grown under shade. Reducing the vegetative long-day treatment period from 7 to 4 weeks had no effect on leaf damage development. Plants treated with paclobutrazol were shorter and had less leaf damage than untreated plants. Leaves of treated plants had a relatively higher concentration of soluble protein, chlorophyll, and enhanced activities of ascorbate peroxidase (AsA), dehydroascorbate (DHA) reductase, and monodehydro-ascorbate (MDHA) reductase than untreated plants. For Texas growing conditions, these preliminary studies indicate that *B. x cheimantha* should be grown under reduced light intensities, with excessive height and leaf damage being controlled with growth retardants such as paclobutrazol.

018

Screening Perennial Bedding Plants for Response to Plant Growth Regulators

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Perennial bedding plant species were tested for response to single treatments of Sumagic (0, 15, 30, 45, or 60 ppm), Bonzi (0, 40, 80, 120, or 160 ppm), Cycocel (0, 750, 1500, 2250, or 3000 ppm) or B-Nine (5000 ppm, applied twice) applied during greenhouse production in Spring 1997. Plant height of both *Chrysanthemum parthenium* and *Malva alcea* had a quadratic response to Sumagic and Bonzi rates, with excessive height reductions at the lowest application rates at 4 weeks after treatment. All rates of Cycocel reduced plant height of *C. parthenium* and *M. alcea* by 33% and 40%, respectively. These species did not establish in the landscape. *Verbena bonariensis* was moderately responsive to Sumagic and Bonzi, but not Cycocel. Application rates of 15 and 30 ppm Sumagic or 160 ppm Bonzi provided moderate height control without landscape persistence beyond 4 weeks after planting. *Leucanthemum x superbum* 'Alaska' was responsive to Sumagic and Bonzi, but not Cycocel or B-Nine. Rates of 15 ppm Sumagic or 40 ppm Bonzi provided moderate control without landscape persistence. Plant height

of *Monarda didyma* 'Blue Stocking' had a linear response to Sumagic and Bonzi rates. Plant height of *Rudbeckia fulgida* var. *Sullivantii* 'Goldstrum' was reduced by Bonzi and Sumagic but not B-Nine or Cycocel, with recommended rates of 30 to 40 ppm Sumagic or 160 ppm Bonzi. Treatment of *Sedum* x 'Autumn Joy' with Sumagic resulted in excessive landscape persistence of growth retardation at all rates, but *Sedum* was not responsive to Cycocel. *Veronica alpina* 'Sunny Border Blue' was responsive to all rates of Cycocel, but growth retardation persisted through 12 weeks after planting.

019

Lupine (*Lupinus polyphyllus*) Flowering Response to Photoperiod and *Hosta* Response to Florel Growth Regulator

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Seeds of 'Russell hybrid' and 'Minarette' mix lupines were sown in three experiments on 3 Sept., 10 Nov., and 2 Mar. under long-day (LD). Seedlings were transplanted on 27 Jan., 11 Mar., and 16 Apr. and moved to natural-day (ND) or LD (1500 to 0200 HR). Plants were either placed in a 17/13C day/night (DT/NT) temperature or 22/18 °C DT/NT greenhouse, and moved monthly to ND or LD for 32 treatment combinations. Days until visible bud, flowering, and vegetative heights were analyzed. 'Minarette' formed flowers more consistently than did 'Russell hybrids', indicating that 'Minarette' populations tend to flower earlier. Young lupines did not respond to photoperiod, but facultative flowering was observed. Foliage height was greater under LD. One-year-old *Hosta sieboldiana* and *H. 'Francis William'* were transplanted with one crown and placed in two temperatures as with lupines. Expt. H1 hostas were placed under LD/ND with no spray, 500 ppm, or 1000 ppm Florel; Expt. H2 hostas were placed under LD with no spray, 250 ppm Florel monthly, 500 ppm Florel at 4-, 6-, or 8-week intervals, or 2500 ppm benzyladenine (BA) sprays monthly (Dec. 1996 to July 1997). *H. sieboldiana* had more offsets than *H. 'Francis William'*, but the latter had increased offsets with Florel sprays. Both cultivars were shorter with 1000 ppm Florel treatments. BA-treated plants were shorter with more offsets than Florel-treated plants.

020

Prefinishing Strategies for Flowering *Petunia x hybrida* Vilm.

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Petunia x hybrida Vilm. 'Purple Wave' and 'White Storm' were grown under different lighting treatments for different lengths of time at different stages of development during the first 4 weeks after germination. The objective of the experiment was to identify the effects of photoperiod and stage of development on date of anthesis and plant form at anthesis. Seedlings were transplanted from 25-cm³ "plugs" into 85-cm³ cell-packs prior to treatment initiation. Plants were grown under ambient photoperiod (April, St. Paul, Minn.) at 20 ± 1 °C before and after treatments. Lighting treatments were 4 weeks of either 9-h ambient light (SD), ambient light plus 100 µmol·m⁻²·s⁻¹ continuous light (CT) provided by high-pressure sodium lamps, or varying combinations of weeks of SD and CT. After 4 weeks of treatment, plants either remained in cell-packs, were transplanted into 10-cm pots (one plant per pot), or 19-cm pots (three plants per pot), and grown until anthesis. Data collected included anthesis date, leaf number below the first flower, lateral shoot number, and flower bud number. A single week of CT was sufficient to induce flowering in 'White Storm'. 'Purple Wave' plants did not flower in response to lighting during the first 2 weeks of development. 'Purple Wave' plants grown under CT during weeks 3 and 4 flowered with a lower leaf number than if grown in SD for all 4 weeks. Consequences of these findings with respect to prefinishing seedlings and scheduling crops of different container sizes will be discussed.

021

Growth and Branching Responses of *Portulaca grandiflora* to Foliar Applications of Chemical Growth Regulators

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During container production of portulaca, growth of long, prostrate, sparsely branched stems makes handling of plants difficult, and reduces their commercial

appeal. Growers prefer to minimize shoot elongation while increasing branching to provide a full, compact plant. The objectives of this study were to evaluate growth regulators for promotion of branching and inhibition of stem elongation. Container-grown plants ≈21 cm in diameter were treated with sprays of ProShear (benzylaminopurine) at 62.4, 125, and 250 ppm; Promalin (benzylaminopurine + gibberellins 4+7) at 125, 250, and 500 ppm; Atrimmec (dikregulac) at 250, 500, and 750 ppm; and Florel (ethephon) at 250, 500, and 750 ppm. These treatments were compared with untreated controls in a randomized complete-block design. Main shoot lengths were measured at 16, 31, and 51 days after treatment (DAT). Numbers of new shoot breaks were counted 16 DAT. The growth habit, that is, tendency to grow upright or prostrate, was also evaluated 16 DAT. The most-effective material for retarding primary shoot elongation and for stimulating secondary shoot development was ProShear. At 16 DAT, 250 ppm ProShear reduced shoot elongation by 25% compared to control plants. This treatment also increased the number of secondary shoot breaks by 143%. Promalin increased the number of new shoot breaks, but it also increased the lengths of all shoots. High rates of Florel and Promalin caused shoots to grow predominantly upright rather than prostrate. ProShear, however, caused more prostrate growth as rate increased.

022

Cyclamen Leaf Unfolding Rate in Response to Temperature

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Nine-week-old plants of *Cyclamen persicum* 'Miracle Salmon' were transplanted into 10-cm pots and placed in growth chambers at 8, 12, 16, 20, or 24 °C. The irradiance was 10 mol/day per m² during a 16-h day length. After 8 weeks, the temperature was changed to 16 °C for all plants. Expanded leaves (1 cm or larger) were counted at weekly intervals for each plant. The rate of leaf unfolding increased with temperature to 20 °C. The fastest rate at 20 °C was 0.34 ± 0.05 leaf/day. Flower buds were visible 55 ± 7 days from start of temperature treatments (118 days from seeding) for the plants grown at 12, 16, or 20 °C. Flower buds appeared 60 ± 6.9 days from initiation of treatments for plants grown at 24 °C and 93 ± 8.9 days for cyclamens grown at 8 °C. Although there was no significant difference in rate of flower bud appearance for cyclamens grown at 12, 16, or 20 °C, the number of leaves, flowers, and flower buds varied significantly among all temperature treatments. Leaf number at flowering increased from 38 ± 4.7 for plants at 12 °C to 77 ± 8.3 at 24 °C. Flowers and flower buds increased from 18 ± 2.9 to 52 ± 11.0 as temperature increased from 12 to 24 °C. Plants grown at 8 °C had on average 6 ± 2 visible flower buds, but no open flowers at termination of the study (128 days from start of treatments).

023

Cyclamen Flower Development in Response to Temperature

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Commercially plug-produced *Cyclamen persicum* 'Miracle Salmon' were transplanted into 10-cm pots 15 weeks from seeding and placed at 16 °C. The irradiance was 10 mol/day per m² during a 16-h day length throughout the study. Three weeks from transplant, the plants were placed at 8, 12, 16, 20, or 24 °C. At the time of temperature change, flower buds were first visible. Time to first open flower decreased with increasing temperature to 20 °C. On average, the cyclamens grown at 20 °C required 60 ± 4.5 days from transplant (165 days from seeding) to first open flower. There was no difference in rate of flowering for the plants grown at 16 or 24 °C (74 ± 9.5 days from transplant). Cyclamens grown at 12 °C required on average 28 more days and cyclamens grown at 8 °C, 45 more days to first open flower compared to plants grown at 20 °C. There was no difference in number of leaves per plant (55 ± 14.4). However, the plants grown at 24 °C had significantly larger leaves and total leaf area per plant (1060 ± 235 cm²) than plants in the other temperature treatments (585 ± 104 cm²). The number of flowers and buds per plant was 45 ± 10.6 for plants grown at 16, 20 or 24 °C. Significantly less flowers and buds were produced by plants grown at 12 °C (34 ± 7.9) or 8 °C (17 ± 3.7).

024

Effect of High Temperatures on the Postharvest Flowering of Specialty Floral Crop Species

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Flower growers experience decreased consumer satisfaction with plant species that cease flowering during the summer. The objective of this experiment was to characterize the heat tolerance of four specialty floral crop species in order to predict their summer performance in the different climatological regions of the United States. The effect of increasing temperatures on the duration of postharvest flower development was determined for *Ageranthemum frutescens* 'Butterfly' and 'Sugar Baby', *Brachycome hybrid* 'Ultra', and *Sutera cordata* 'Snowflake'. Plants were grown in a 18 °C greenhouse until marketable with foliage covering the container and flowers distributed evenly across the plant canopy. Plants were then placed in a phytotron to determine their heat tolerance. Temperature set points of 18, 23, 28, and 33 °C were delivered serially at 2-week intervals, starting at 18 °C. Plants were then returned to 18 °C after the 33 °C treatment. Immature flower bud, mature flower bud, flower and senesced flower numbers were collected once per week. *Sutera* 'Snowflake', and *Brachycome* 'Ultra' had the greatest flower number at the 23 °C temperature, decreasing in the 28 °C environment. *Argeranthemum* 'Butterfly' and 'Sugar Baby' had greatest flower number at 28 °C, but flowers were smaller and of lower quality than at 23 °C. Flower development of all cultivars ceased at 33 °C, but when plants were returned to the 18 °C production greenhouse, flower development resumed. According to normal average daily temperatures in Knoxville, Tenn., *Ageranthemum frutescens* 'Butterfly' and 'Sugar Baby' would flower until mid-June, while *Brachycome hybrid* 'Ultra' and *Sutera cordata* 'Snowflake' would flower until mid-May.

025

Effect of Temperature on Cutting Production of 10 Hanging-Basket Crops

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Stock plants of *Argeranthemum frutescens* 'Butterfly' and 'Sugar Baby', *Brachycome hybrid* 'Ultra', *Helichrysum bracteatum* 'Golden Beauty', *Scaevola aemula* 'New Wonder', *Petunia axillaris hybrids* 'Purple Sunspot' and 'Blue Vein', *Sutera cordata* 'Mauve Mist' and 'Snowflake', and *Verbena hybrid* 'Blue' were grown in glass greenhouses under five different temperatures (17, 20, 23, 26, or 29 °C) and a 13-h photoperiod. Cuttings were taken two to three times per week. Total cutting production increased as temperature increased. However, different varieties showed different temperature response patterns. Cutting production in *Argeranthemum* and *Brachycome* was relatively insensitive to temperature. For *Brachycome*, *Helichrysum*, *Scaevola*, *Petunia*, *Sutera*, and *Verbena*, cutting production in the 29 °C treatment was double or triple that in the 17 °C treatment. For all tested species, the highest cutting production was in the 29 °C treatment. Although cuttings produced in the 29 °C treatment tended to have a soft stem, rooting was not affected by temperature under which stock plants were grown.

026

Stock Plant Environment Impacts Lateral Stem Strength of Finished Poinsettias

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Previous work indicated that the cutting source impacted lateral stem strength of the finished poinsettia. The objective of this experiment was to determine the effect of the stock plant environment on the stem strength of the harvested cuttings. Stock plants were grown in two greenhouses. The night temperature was maintained at 20 °C in both, while the day temperature was maintained at 30 or 37 °C. Two irradiance levels were maintained with each greenhouse: 50% and 75% shade cloth. Within each irradiance treatment, individual stock plants were provided 522, 929, or 1451 cm² of bench space. Stock plants were pinched to 12 nodes, lateral shoots developed, and cuttings were harvested. The cuttings were propagated, transplanted and pinched. Lateral stem strength was quantified by dropping the finished plants from progressively greater heights and recording stem breakage. Stem strength increased as temperature increased, irradiance increased, and as stock plant density decreased. Plants grown in the lower temperature, lower irradiance level, and higher plant density experienced 34% of the lateral shoots breaking off at a 30-cm drop height, while 4% of the lateral shoots broke on the cuttings harvested from the higher temperature, higher irradiance, and lower plant density treatment.

027

GHSIM Developed in Spreadsheet Quattro Pro Simulates the Interactive Greenhouse

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A computer model, GHSIM, was formulated in Quattro Pro spreadsheet format. GHSIM was designed having individual pages calculating simulated activities necessary for greenhouse production. Pages were arranged by alphabetical topics starting with the "Area" used in the greenhouse. Time advanced by 1 day for each 10 s of real time. The time advance in the program can be paused to make setting changes interactively. Pest infestation occurred as probabilities accumulated, and the pest population spread through the greenhouse based on proximity and density of pests. Pest control was simulated by a pesticide application capable of partially reducing populations; repeated applications could effectively eliminate a pest. Crop growth was simulated by iterative accumulation of biomass using Euler integration of daily plant growth. The daily growth increment was calculated using the first derivative of the Richard's Function. Large pest populations negatively impacted the daily growth increment, and pesticide applications would remove the inhibition of growth. Additional features proposed include light and temperature effects on the plant growth rate and accumulated biomass.

42 POSTER SESSION 1C (Abstr. 028–035) Nutrition—Woody Ornamentals/Land- scape/Turf

028

Effect of Phosphorus Applied as a Controlled-release Fertilizer or Soluble Fertilizer to a Container Nursery Crop

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Thirty commercially propagated bareroot cuttings and 30 cuttings with growing medium around the roots of Halwards' Silver Spiraea were fertilized with various phosphorus fertilizers to determine the effect of fertilizer type on P leaching and on plant quality. The following treatments were applied: 1) 100% controlled-release fertilizer (CRF) consisting of 22N–6P–14K; 2) 50% CRF consisting of 22N–3P–14K plus 50% soluble fertilizer (SF) consisting of 0N–46P–0K, triple superphosphate (TSP); and 3) 100% SF consisting of 22N–0P–14K plus TSP (0N–46P–0K). There was a significant plant by fertilizer interaction for leachate P content. Cuttings with medium and bareroot cuttings receiving 100% SF had a higher concentration of P in leachate; while the cuttings with medium receiving 100% CRF and 50%CRF/50%SF had lowest P concentration in leachate. Plants grown with 50%CRF/50%SF had larger root dry masses compared to the plants grown in 100% CRF and 100% SF. Plants grown in 100% CRF had the smallest stem dry masses compared to the other fertilizer treatments. Plants containing 100% CRF had a lower P concentration in the stems compared to plants containing 100% SF and 50% CRF/50% SF.

029

Mulch and Fertilizer Application Method Influence on Plant Growth in Winter Annual Plantings

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A winter planting of pansies, *Viola x witrockiana* Gams, was established in existing landscape beds to determine mulch type and fertilizer application method influences on plant growth. Two cultivars, 'Bingo Blue' and 'Bingo Purple', were planted in beds containing four different mulches (cottonseed hulls, cypress wood, pine bark, pine straw). A split application of fertilizer by three application methods (granular, liquid, time-release) was applied at planting for plant establishment and in the spring to encourage new growth. Fertilizer was applied either below the mulch on the soil surface or over the mulch surface. Cottonseed hulls, cypress wood, and pine bark delayed soil warming in the spring and the effectiveness of all fertilizers. The use of time-release fertilizer below all mulches improved growth. Pine straw allowed soil temperatures to rise and fertilizer to increase plant dry

weight accumulation. Rapid decomposition of pine straw resulted in a 0.55-unit decrease in soil pH and increases in soil nitrogen and EC values.

030

Effect of Organic and Mineral Mulches on Soil Properties and Growth of Red Maple

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Five mineral mulches (crushed red brick, pea gravel, lava rock, carmel rock, and river rock) and three organic mulches (finely screened pine bark, wood chips, and shredded hardwood bark) were evaluated over 2 years to determine their influence on soil temperature, moisture, and pH, and to quantify their effect on growth of Fairview Flame® red maple (*Acer rubrum* L.). Mulch treatments (2.3-m² plots of eight mulches and a non-mulched control) were randomly applied to trees in five blocks. Organic mulches were placed directly on bare ground, while mineral mulches were underlaid with a woven polypropylene fabric. Soil temperature was highest and soil moisture lowest under the mineral mulches and non-mulched control. Soil pH was highest under shredded bark (6.82) and wood chips (6.81), and lowest in the non-mulched control (6.03). Despite such differences in the root-zone environments, there were no significant differences in stem caliper or tree height, but leaf dry mass was greatest for trees treated with mineral mulches.

031

Release of Mineral Elements and Heavy Metals Restrained in Organic Residues and Their Effects on *Physocarpus opulifolius* 'Nanus' Grown in Containers

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The use of waste in ornamental culture seems to be the best optional method of disposal. However, the amount of available mineral elements in organic residues is not equilibrated with the mineral needs of plants. In this context, this study was performed to evaluate the influence of fresh bio-filters (FBF), composted sewage sludges (CSS), and composted de-inked sludges (CDS) on the mineral composition of substrate water solution. Substrates containing 10% of each organic residues and control substrate (4 peatmoss, 5 composted conifer bark, and 1 fine crushed gravel, by volume) were potted in 5-L containers. An experiment was conducted with *Physocarpus opulifolius* 'Nanus' plants and a soluble fertilizer 20N-20P-20K (400 mg/L of N). Another experiment was carried out without plants and without fertilization. In the two experiments, the four substrates were randomized in a complete block design with six replications. All containers were watered every 2 weeks until leaching (inspired by the pour-through method described by Wright, 1986) and a sample of each leachate was collected for analysis. Growth parameters were statistically analyzed. The content of nutrient elements in the water solution of substrates with plants and with fertilization was higher than their content in the water solution of substrates without plants and without fertilization. However, the content of heavy metals was quite similar with the two fertilization regimes and was below the undesirable limits. Substrates amended with CSS released a higher quantity of P, K, S, and Na than substrates amended with FBF or CDS. Moreover, *Physocarpus* plants grown in CSS were significantly larger than those plants grown in the control substrate. The results obtained in media containing FBF or CDS were similar to those obtained in the control substrate.

032

Assessment of Biologically Converted Swine Waste as a Fertilizer Source in Container Production

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Swine waste (SW), the by-product of North Carolina's booming hog industry, is one of the state's most underutilized resources. Currently, SW is used to grow coastal bermuda hay, a "disposal" crop with little to no economic value. Use of SW by commercial growers as fertilizer would reduce the need to dispose of SW and could reduce the overall input of nutrients into the environment. Our objectives were to determine: plant growth characteristics of SW, the effects of SW on leachable forms of nitrogen, and the physical effects of SW in a pine bark media. To avoid pathogens, we used SW (BionSoil™) that had been biologically

digested as part of a proprietary SW treatment process (Bion Technologies, Inc.). Liners of 'Rose Madness' petunia, 'Skogholm' cotoneaster, 'Girard's Red' azalea, and 'Wilson's Yellow' daylily were planted in 3.8-L plastic pots that contained one of the following (by volume): 10% SW:90% pine bark, 20% SW:80% pine bark, 30% SW:70% pine bark, or pine bark (control) amended with 3.6 kg of 23-4-8 controlled release fertilizer (CLF), 3.6 kg dolomitic limestone, and 330 g micronutrient fertilizer per m³. Shoot dry weights were determined for all species at harvest. Root dry weights were obtained for cotoneaster and daylily. Leachate nitrogen and pH was determined periodically throughout the 22-week study. By the 14th week, nitrogen and potassium deficiencies were identified on plants growing in SW-amended media. Those treatments were subsequently toppedressed with a corrective application of 9 g of 23N-4P-8K CRF. Generally, SW can produce plants similar to short-term CRF without the need for supplemental micronutrients or lime. Root biomass was greater in SW media than in the control. A mid-season application of a N-P-K fertilizer may be necessary.

033

The Response of Bermudagrass (*Cynodon* spp.) to Microorganisms and Humate Soil Inoculations

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Effects of soil inoculations of selected beneficial microorganisms and humate materials on root mass, shoot growth, and turfgrass quality of a 6-month-old bermudagrass (*Cynodon dactylon* L. cv. Tifway) stands growing on microplots in Kingsville, Texas, were studied. *SuperBio + Humus soil inoculant formulated by Ag-Technology Inc., was used in this study. Various levels (0, 1/4, 1/2, 1, and 1.5 gallons per acre) of the *SuperBio product were injected into the soil with irrigation water on weekly basis. Prior to the treatments, five 7.62-cm plugs were removed from each of the microplot for root and shoot growth analysis. Plug samples were subsequently taken every 4 weeks after the treatments. While all treatments, except the controls, showed increase in shoot growth, only 1 gal/acre treatment gave significant increase in root mass as compared to the other treatments including the controls. It appears that visual turfgrass quality ratings increased with an increase in treatment levels.

034

Colonization Potential of Ornamental Plants by Three Vesicular-Arbuscular Mycorrhizal Fungi

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Roots of majority of natural shrubs are colonized by many species of vesicular-arbuscular mycorrhizal (VAM) fungi. These kinds of fungi form a symbiosis with the root system of the plant and give a better water and mineral absorption (P, Zn, N, Cu, etc.), and a better root disease resistance to the plant. However, the media usually used in ornamental plants nursery contain no or few mycorrhizal fungi. For now, new commercial inoculum are available and could be used to get the advantages provided by VAM fungi. In order to evaluate the potential of ornamental plants to be colonized, we have inoculated the rooting media with three VAM fungi (*Glomus intraradices* Schenk & Smith, *Glomus etunicatum* Becker & Gerdemann, and *Glomus mosseae* Nicol. & Gerd.; Premier Tech, Rivière-du-Loup, Québec). The inoculum proportion used contained about 1500 propagules/L. After 16 weeks, near 80% of the 200 species and cultivars tested have shown a colonization by at least one of the fungi. We shall present here a list of the results.

035

Comparison of Nodular Efficiencies Between Partridge Pea and Soybean Using Acetylene Reduction

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Legumes are grown as nurse crops in agriculture because they increase soil microbial life and productivity. Native legumes have potential in ecological restoration to mimic the benefits found in agriculture plus they enhance the restored ecosystem. This study was initiated to compare the growth rates, nodulation characteristics, and nitrogen fixation rates of a native versus a non-native legume. The two legumes were partridge pea (*Cassia fasciculata*); a native, wild, annual legume and soybean (*Glycine max* 'Century Yellow'); a domesticated, agricultural, annual legume native to Asia. Plants were grown for 11 weeks in pots containing

silica sand and received a nitrogen-free Hoagland's nutrient solution. Beginning at week 12, plants were harvested weekly for four consecutive weeks. Nodulated root systems were exposed to acetylene gas and the resulting ethylene amounts were measured. The two legumes exhibited significant differences in nodule size and shape and plant growth rate. In soybean, nodules were large, spherical, and clustered around the taproot while in partridge pea, nodules were small, irregularly shaped, and spread throughout the fibrous root system. Soybean plants had a significantly faster growth rate at the onset of the experiment but partridge pea maintained a constant growth rate and eventually exceeded soybean plant size. In spite of these observed differences, partridge pea and soybean plants were equally efficient at reducing acetylene to ethylene. These results indicate partridge pea has the potential to produce as much nitrogen in the field as soybean. Native legumes such as partridge pea deserve further research to explore their use as nurse crops in agricultural or restoration regimes.

42 POSTER SESSION 1D (Abstr. 036–042) Management—Wildflowers/Miscellaneous

036

Regulatory Oversight of Natural and Alternative Landscapes

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In their attempts to be more environmentally sensitive, many thousands of homeowners propose, or actually implement, alternatives to conventional lawn maintenance. In many cases, the perception of "naturalness" incorporates unmowed grasses and forbs believed by the homeowner to be reminiscent of fields and pastures. A previous study of municipal attitudes toward this phenomenon revealed a wide variety of responses, ranging from laissez-faire, through official recognition and registration to strict prohibition and vigorous enforcement. The current expansion of this study focused on larger cities and their suburbs, especially newer subdivisions. In contrast to the general air of tolerance expressed by many smaller, midwestern towns for alternative landscape plans, provided they are well-maintained, larger cities and suburbs appear generally much less tolerant of nonstandard lawn maintenance. Failure to maintain lawn grasses at a standard height will almost certainly lead to enforcement of lawn maintenance and weed control ordinances in a majority of the cities surveyed, no matter what the intentions of the homeowner.

037

Historic Military Landscapes: A Design and Management Opportunity

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The United States Army has recently recognized the evaluation and management of historic military landscapes as an integral component of cultural resource management. The process of properly assessing and managing military landscapes, however, can be problematic due to the need to preserve the historic character of the landscape, to enhance the military image and to improve quality of life. In addition there is a desire to implement "... environmentally and economically beneficial landscape practices on Federal properties..." as set forth in a memorandum from the President. USACERL recently completed an historic landscape inventory and management plan for Fort Sam Houston, Texas. The landscape master plan was awarded the Texas Historical Commission's Award of Excellence in Historic Architecture. The management plan provides historically and ecologically sensitive designs that relate to each of the periods represented in the installations' historic district. Included are appropriate plant lists and guidelines for enhancing the image of the base and improving quality of life for residents and installation personnel. Of some concern here, as in many Southwest installations, is the overuse of irrigation in historic areas, and the need to replace ecologically (and historically) inappropriate plants with more drought-tolerant species. Plan implementation in these areas is expected to reduce both water usage and associated costs.

038

Consumer Preferences in Mixed Prairie Wildflower Plantings

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A goal of this study is to establish temporal evaluations of the problems homeowners may encounter when establishing mixed prairie wildflower plantings. These plantings are often attempted with the notion that the composition of the planting will remain static over time with little or no maintenance. Six combinations of wildflowers and prairie grasses were compared for consumer preference. A survey was conducted at the long-term forbs research plots during the Festival of Color, an open house event at the John Seaton Anderson Turfgrass and Ornamental Research Area, Univ. of Nebraska Agricultural Research Development Center near Mead, Neb. Of the 9000 participants in the festival, ≈850 visited the plots. Of those, nearly 300 completed the survey instrument. Results from the first year indicate that the majority of respondents were homeowners who do their own yard work. Most of them considered a low maintenance landscape to be an important way in which to conserve resources such as water and fertilizer and reduce pesticide use. Most had grown prairie wildflowers and considered them to be low maintenance. The study showed that, depending on the planting composition, it would require between 59 and 118 h of weeding to establish wildflowers in the majority of respondents' home landscapes, which were between 1717 m² and 1525 m². The majority (56%) of visitors preferred combinations that included annuals but excluded prairie grasses. The majority (66%) disliked the combinations of prairie grasses without the inclusion of wildflowers.

039

Wildflower Seed Source Affects Performance of Six Wildflower Species

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Field plantings of six native wildflower species were established at five sites in 1997 from seeds derived from local native populations (local ecotype) and from seeds purchased from commercial sources outside of Florida (nonlocal ecotype). The species were *Cassia fasciculata* (partridge-pea), *Coreopsis lanceolata* (lance-leaf coreopsis), *Gaillardia pulchella* (blanketflower), *Ipomopsis rubra* (standing cypress), *Rudbeckia hirta* (black-eyed susan), and *Salvia lyrata* (lyre-leaf sage; cancer weed). They were evaluated once per month from June to Oct. 1997. Plantings were maintained as follows: no supplemental fertilization; irrigation as needed up until early April to ensure germination; no pesticides except to control fireants and weeds on the perimeter of the plantings; plots were handweeded as necessary. It was clearly evident from these evaluations that the local ecotypes generally were better adapted to north Florida conditions than were the nonlocal ecotypes. The most noteworthy differences were as follows: 1) the local ecotypes of *Rudbeckia* and *Gaillardia* had longer flowering periods than their nonlocal counterparts, 2) the local ecotype of *Coreopsis* flowered profusely while flowering of the nonlocal ecotype was sparse, and 3) the local ecotypes of *Coreopsis* and *Salvia* had less disease incidence than their nonlocal counterparts.

040

Identifying Native Prairie Grass Seedlings

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There is great interest in prairie gardens and prairie restorations in the central United States. Small prairie gardens are often established with plugs, but most restorationists and landscape contractors use seed for large plantings. If initial establishment is poor, restorations are often interseeded the second or third season. However, to evaluate early establishment and determine if interseeding is necessary, contractors must be able to identify native grasses in the seedling and juvenile stages. In this study we investigated vegetative characteristics of native prairie grass seedlings. Seven species of native prairie grass were grown in the greenhouse: *Andropogon gerardii* (big bluestem), *Sorghastrum nutans* (Indian grass), *Panicum virgatum* (switch grass), *Schizachyrium scoparium* (little bluestem), *Bouteloua curtipendula* (sideoats grama), *Elymus canadensis* (Canada wildrye), and *Bromus kalmii* (Kalmis brome). Every 2 to 3 weeks after germination, seedlings were photographed, pressed, and mounted. Additional photographs were taken through the dissecting scope at key stages of development. Ligules

and auricles were found to be useful in distinguishing species, and our close-up photographs highlight these structures. Hairiness and color were variable within a species and could not be used reliably in identification. A seedling identification key will be presented for the species studied.

041

Improved Fiber Pots for Container Nursery Production

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There is an increasing interest in the use of fiber pots to grow containerized nursery plants. Of particular interest is the ability to incorporate chemicals to modify plant growth, reduce microbial decomposition, and alter fiber structure. Four perennial plants *Forsythia* 'Spring Glory', *Baptisia australis*, *Ilex meserveae* 'Blue Girl', and *Coreopsis rosea* were grown in 2.3-L fiber containers. Containers were treated with $\text{Cu}(\text{OH})_2$ (Spin Out[®], Griffin Corp.) at 1500 or 3000 ppm, TCMBT (Busan[®] 30WB fungicide, Buckman Lab.) at 1700 or 3400 ppm, and combinations of $\text{Cu}(\text{OH})_2$ and TCMBT. Untreated plastic and untreated fiber pots were used as controls. Plants were grown in a commercial nursery in central Pennsylvania for 5 months during the 1997 growing season. Plants were harvested in the fall. Data included: root penetration of pot walls, plant growth, pot strength, medium root distribution, and root zone temperatures. Results with TCMBT were inconclusive. However, $\text{Cu}(\text{OH})_2$ -treated pots had fewer penetrating roots and were stronger. Root zone temperatures in fiber pots were lower.

042

"Cold-Trapping" in Retractable Roof Structures To Avoid Spring Frost Damage of Container-grown Nursery Crops

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Compared to film-covered quonset structures typically used for unheated cold protection of nursery crops in Oregon, unheated retractable roof structures can provide cooler day temperatures (lower average daily temperature, ADT) in late winter and early spring. Late winter and spring growth and flowering of six nursery genera (12 replicate blocks), and air temperatures, were studied when crops were cold-protected in a film-covered quonset structure compared to a retractable roof cold protection structure operated using predawn "cold-trapping." Compared to the quonset structures, retractable roof structures had lower daily maximum temperatures, lower ADT, and similar daily minimum temperatures. Shoot growth of all crops was delayed by 2 to 4 weeks, and flowering of *Rhododendron* 'Hino Crimson' was delayed by 4 weeks, in the retractable roof structures. *Erica* 'Irish Bells' had symptoms of cold-damage and did not flower when protected in the quonset structure, compared to no damage and full-flowering when protected in the retractable roof structure. *Arctostaphylos* had more leaf spots, and less growth in the quonset structures compared to the retractable roof structures. Our hypothesis is that the lower ADT in the retractable roof structures delays de-acclimation to cold temperatures (delaying vegetative and flower budbreak), providing extended protection to frost damage. Higher relative humidity and higher daylight temperatures in the quonset structures may leave the earlier new growth and flowering of nursery crops more susceptible to frost damage and disease infestations compared to the daily vented and cooler retractable roof cold-protection structures.

42 POSTER SESSION 1E (Abstr. 043–047) Growth/Development/Productivity — Fruit

043

Regrowth Performance of Apple Nursery Plants in Relation to Reserve and Current Uptake of Nitrogen

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Gala/M26 apple plants previously treated with foliar urea (0%, 2%, and 4%) were fertigated with or without ¹⁵N-depleted ammonium nitrate by using a modified Hoagland solution after transplanting in the spring. Plants with high N reserves had significantly greater growth than plants with low N reserves. More nitrogen was remobilized for new shoot and leaf growth in plants with high N reserves

than plants with low N reserves. The amount of reserve N used for new shoot and leaf growth was not affected by current supply of nitrogen. There was no significant difference in the amount of nitrogen from current uptake used for new shoot and leaf growth between low and high N reserve plants up to 80 days after spring budbreak. The amount of N from current uptake for new shoot and leaf growth was negligible at 20 days after budbreak. Plants with low N reserves were more dependent on current uptake for sustaining new shoot and leaf growth and maintaining their nitrogen status than plants with high N reserves. After 80 days of growth, plants with low N reserves did not catch up with the plants with high N reserves.

044

Influence of Initial Seedling Size and Rate of Nitrogen Fertilizer on the Growth of Containerized Pecan Trees

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Pecan seedlings were randomly selected and divided into two lots according to size. Seven rates and three sources of nitrogen based fertilizers were applied four times starting on 6 May, 20 June, 4 July, and 15 Aug. Leachates were taken 3 weeks after each application. The pH range after the first application ranged from 6.0 to 7.0. After the fourth the pH had dropped to a range of 5.0 to 6.0. The TDS ranged from 0 to 6.0 mS after the first application to a 2.1 to 0.5 mS after the last application. Growth rates varied slightly among treatments. The average growth rate among seedlings was only slightly affected by nitrogen fertilize rates. Within 12 weeks the average growth was 1.3 mm. There were only slight differences in growth between the low and high rates of $\text{NH}_4 \cdot \text{NO}_3$ fertilizer. The growth rate decreased somewhat in response to increased rates of application of $\text{Ca} \cdot \text{NO}_3$.

045

Effect of Four Training Systems on Growth and Productivity of 'Cortland'/M.9 EMLA Apple Trees

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'Cortland'/M.9 EMLA trees were planted in 1991 at 1.8 X 4.2-m spacing. The trees were trained to one of four systems: 1) Vertical Axis; 2) Y trellis; 3) Solen; or 4) Palmette trellis. Tree survival was 86% for Palmette trees and approached 100% for the other three systems. Annual yield and cumulative yield per tree of Vertical Axis and Y trellis was twice that of Solen or Palmette. Tree vigor was sub-optimal relative to planting distance in this study. Trunk cross-sectional area of Vertical Axis trees was larger than that of trees trained to Solen or Palmette, while trees trained to Y trellis were intermediate in trunk growth. Canopy volumes of Vertical Axis and Y trellis trees were similar, and greater than that of Solen or Palmette trees. Fruit size on Solen and Palmette trees was larger than that of Y trellis trees in 1995 and 1996, while fruit size on Vertical Axis trees was intermediate. Cumulative yield per cubic meter of canopy volume was the same for all four systems, suggesting that differences in productivity among systems were attributable to the effects of tree training practices on tree size, not to differences among systems in precocity or efficiency. The low heading cut needed to establish the lowest tier of branches on the Palmette system reduced tree vigor and in some cases, resulted in mortality. The horizontal training of the primary branches of the Solen severely reduced tree vigor. In this study, where tree vigor was sub-optimal due to rootstock selection, the additional restrictions in tree growth resulting from restrictive training methods resulted in a significant loss in productivity.

046

Managing Vegetative Growth of Apples with Prohexadione Calcium can Influence Mid-season Spray Coverage

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Prohexadione calcium (BAS 125W or Apogee[™]) is a plant growth regulator being developed to control vegetative growth in apples. Prohexadione calcium acts within a plant by blocking the biosynthesis of growth-active gibberellin. The result is decreased cell elongation; thus, reduced shoot length. Applications of prohexadione calcium beginning when the apple trees have 2 to 15 cm of new shoot growth significantly reduce seasonal vegetative growth. Mid-season measurements of air blast spray coverage using water-sensitive cards show that trees previously treated with prohexadione calcium have greater spray coverage within the tree canopy than untreated trees. Hence, more efficient crop protection

can be expected in apple trees treated with prohexadione calcium.

047

Harvest Field Sizing as a Technique to Remove Undersize French Prunes

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Overall profitability is a major goal in successful prune production and a major component in any prune management system. Large prune crops in 1996 and 1997 have stimulated considerable interest in undersize fruit. Undersize prunes currently have marginal value and may represent a net loss because of costs to haul, dry, and to market order payments on low value prunes. One technique to control delivery size is to field size at harvest. Field sizing involves installing size-sorting devices on harvesters, which allow small prunes to fall out while valuable fruit is collected. Field sizing is considered a "risky" strategy because of the potential to remove prunes with economic value. During the 1997 harvest, 21 infield harvest sizing evaluations were made in prune orchards throughout Tehama county. The first evaluation occurred on 12 Aug. 1997, at the start of prune harvest. The final evaluation was done on 5 Sept. 1997, at the tail end of harvest. The objective was to sample throughout the harvest period to test field sizing under various sugar, size, and fruit pressure scenarios. The test machine was 1-inch bar sizer. Of the 21 sample dates, undersize fruit was clearly not marketable in 20 of the 21 samples. Discarded fruit averaged 133 dry count per pound. Only one sample out of 21 may have had market value at 86 dry count per pound. Although small in size, these prunes had very high sugar content contributing to their dry weight. In this evaluation, a 1-inch bar sizer did a good job of separating fruit with and without market value under the 1997 price schedule. As harvest date becomes later and soluble solids increase, the chances of sorting out marketable prunes also increases.

42 POSTER SESSION 1F (Abstr. 048–061) Crop Physiology/Temperature Stress— Cross-commodity

048

The Presence of Heat-shock Proteins in Sun-exposed and Heat-treated Apple Fruit

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Sunburn of apples is frequently a significant cause of cullage in Washington State. Some cultivars are more susceptible to sunburn than others. Further, apples that have acclimated to full sunlight exposure in the field ("sun") have been reported to be less likely to sunburn when exposed to full sunlight than apples growing within the canopy ("shade"). We hypothesize that heat-shock proteins (HSPs) might be involved in these differences in sunburn susceptibility. Western blots of total protein extracts from apple peel identified the presence of protein recognized by antibodies raised against small HSPs (smHSPs) from different plant species. SmHSPs in apple were very low or non-detectable in "shade" fruit, but were relatively high in "sun" or heat-treated (4 h at 40 °C) "shade" fruit. SmHSP accumulation in 'Fuji' apples could be detected after the first hour of a 4-h heat treatment at 40 °C, and continued to increase over the next 8 to 10 h. The smHSPs did not begin to decline even after the apples had been held for 48 h at room temperature. Initial studies indicate that cultivars differ in smHSP content. Results from biweekly samplings of several cultivars will be reported.

049

Temperature Effects during Endodormancy Induction on Subsequent Anthesis and Growth of Peach Trees

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Mature peach trees in pots were treated with nighttime temperatures of -3, 6, 12, and 18 °C for 16 h and a daytime temperature of 20 °C for 8 h until the leaves

abscised in the colder treatments. The trees were then chilled at 6 °C for 40 to 70 days. Trees were removed from chilling at 40, 50, 60, and 70 days and placed in a 20 °C greenhouse under increasing daylength, spring conditions. Anthesis was faster and shoot length increased with longer chilling treatments. Trees exposed to -3 °C pretreatment flowered and grew best with 40 days of chilling. However, they did not flower faster or grow better than the other treatments with longer chilling times. There was no difference in flowering or growth between the 6 and 12 °C pretreatments. The 18 °C pretreatment resulted in slower flowering and very little growth after 40 and 50 days of chilling, but growth was comparable to other treatments after 70 days of chilling.

050

Effects of Decreasing Temperature and Photoperiod on Carbohydrate Reserve Accumulation and ¹⁴C-Photosynthate Partitioning in Apple

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Carbohydrate reserves are major substrates for cold hardiness and respiration during winter and for early growth during the following season for most woody plants. In apple, carbohydrate reserve accumulation occurs mainly in late summer and autumn as temperature and photoperiod decrease. However, information on the response of reserve carbohydrate accumulation and photosynthate partitioning into sorbitol, sucrose, and starch in apple to decreasing temperature and photoperiod is limited. One-year-old 'Gala' apple plants were grown in controlled environments at 26 °C and 16-h photoperiod for 50 d and then either remained in 26 °C/16 h or were subjected to a lower temperature and shorter photoperiod for 28 d that resulted in four treatments of 26 °C/16h (HT/LD), 26 °C/8h (HT/SD), 13 °C/16h (LT/LD), 13 °C/8h (LT/SD). Newly fixed ¹⁴C-photosynthates and reserve carbohydrates were analyzed in leaves, stems, and roots. Leaf photosynthesis and plant growth parameters were also examined. The LT treatments inhibited plant shoot growth and leaf initiation rates while SD treatments had little additive effect. Plants with LD treatments had greater specific leaf weight, but decreased photosynthetic rates compared to SD regimes. A decrease in temperature altered partitioning of newly fixed ¹⁴C-photosynthates into sorbitol, sucrose, and starch and carbohydrate accumulation in various plant organs. Low temperature effects were modified by photoperiod.

051

The Influence of Temperature and Low Light on Fruit Set and Chemical Thinning of Apple Trees

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Fruit trees grown in the eastern U.S. environment are typically exposed to low light conditions from cloudy/rainy periods that can reduce PAR to 10% to 15% of full sun for 2 to 3 days. To magnify or concentrate the effect of temperature during low light stress, fruit trees were moved from the field into total darkness for 2 to 4 days at various temperatures and then returned to the field. This provided low light stress while eliminating the need for treatments involving various levels of light and temperature during the day on photosynthesis. To reduce transplanting shock, bearing apple trees used were grown in the field in 25-cm-diameter root bags and were on M.27 rootstock. After initial fruit set (at about 15 mm fruit diameter) trees were dug and transplanted into 5-gal buckets and moved for short periods of time (2 to 4 days) into various dark environments or sprayed with various thinning chemicals and placed in growth chambers at 5, 10, 16, and 21 °C in the dark. Immediately after dark treatments, trees were returned to the field and placed in the original holes. In 1995, we found that Elstar/M.27 apple trees placed in the dark for 3 or 4 days and returned to natural sunlight conditions abscised all of their fruit at 21 °C dark temperature but were retained at 5 °C. In 1996, we found that Braeburn/M.27 apple trees placed in the dark for 2 days and returned to natural sunlight conditions abscised all of their fruit at 16 and 21 °C dark temperature, but were retained if the dark period was 5 °C. These data indicated that the dark period temperature was very important for fruit retention. In addition, trees sprayed with Carbaryl+Accel 3 h before placing in the growth chambers caused the development of more pigmy fruit at all temperatures. Pigmy fruit also appeared to be related to the combined effects of digging trees, treating with Carbaryl + Accel, and colder temperatures. In 1997, we found that Stayman/M.27 apple trees placed in the dark for 2 days and returned to natural sunlight conditions abscised most of their fruit

at 21 °C dark temperature, but were retained if the dark period was 5 °C. Fruit thinning occurred at 10 and 16 °C. Additional fruit thinning was significantly promoted by Carbaryl or NAA + Regulaid over the range of temperatures (5 to 21 °C), but thinning appeared to be most promoted at 21 °C dark temperature. Unexpectedly, ethephon caused fruit thinning at all temperatures from 5 to 21 °C, and thinning did not appear to be affected by temperature (ethephon defruited all trees at all temperatures). We suspect that higher dark temperatures caused either higher respiration rates or higher natural ethylene production, which promoted fruit abscission whether treated with a thinner or not. In one field experiment, Carbaryl sprays were applied at 2-h intervals beginning at 6 a.m. until 8 p.m. to Empire/Mark trees. Similar fruit thinning occurred when applied at temperatures ranging from 18 to 36 °C. These data suggest that no differences in thinning were related to daytime temperature.

052

Effects of Soil Temperature and Drought on Root–Soil Respiration in Apple under Field Conditions

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Root respiration is very important to root efficiency, root lifespan, and carbon cycling in plant ecosystems. Yet, the effects of soil temperature and moisture on root respiration are poorly understood, especially under field conditions. In this study, we manipulated soil temperature and moisture by six bearing 'Red Chief' Delicious/ M26 trees near State College, Pa. Soil temperature was elevated 5 °C at 5-cm depth using circulating hot water and stainless steel grids. Soil temperature was monitored using thermocouples and a data logger, and soil moisture was monitored using TDR. Root–soil respiration was determined by static trapping at the soil surface. Heating was conducted from 8 May to 28 Oct. Drought was initiated on 21 Aug. and lasted 2 months. Root–soil respiration was lowest in spring and increased from June to late August. After September, respiration decreased until the experiment ended in November. Root–soil respiration was not correlated with root length density. Heating enhanced root–soil respiration about 15% to 20% in spring (May) and 10% in summer (June–August). After the drought treatment began, heating increased root–soil respiration about 42% in wet soil, but did not influence respiration in dry soil. Heating accentuated the effect of the drought treatment on soil moisture. After 2 months of no irrigation and no rain, soil moisture was reduced 5% in unheated soil and 10% in heated soil. Drought slowed root–soil respiration 17% in unheated soil and 36% in heated soil, mainly because heating increased respiration in wet soil, but compared to the unheated treatment, had no effect in dry soil.

053

Freezing Tolerance in *Rhododendron* and Its Association with Dehydrin Expression

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This study examines whether dehydrin expression in leaves is associated with varying levels of cold hardiness among evergreen rhododendrons. Initially, differences in leaf freezing tolerance (LFT) were determined within three groups of plants: 1) a cultivar group; 'Chionoides' (CND), 'Grumpy Yellow' (GY), and 'Vulcan's Flame' (VF) 2) a segregating F₂ population derived from a super cold-hardy (*R. catawbiense*) x less-hardy (*R. fortunei*) cross, and 3) juvenile seedlings and mature plants of wild-collected *R. maximum*. LFTs in fully acclimated cultivars corresponded with their USDA hardiness zone ratings—CND (zone 4, –32 °C) GY (zone 7, –16 °C), and VF (zone 6, –19 °C). F₂ segregation was characterized by a continuous, normal distribution of LFT values, with groups of progeny at the "tails" differing in their mean LFT by 20 °C. Juvenile seedlings of *R. maximum* exhibited LFTs that were 12 °C lower than LFTs from mature plants. Western blots of leaf proteins revealed a common 50-kDa dehydrin that accumulated during cold acclimation in all three cultivars and appeared to be quantitatively associated with LFTs. Isoelectric focusing of the 50-kDa *Rhododendron* dehydrin revealed two isoforms (pI 5.5 and 6.5). The more acidic isoform was detected only in the hardiest (CND) cultivar. Experiments are underway to examine qualitative and quantitative expression of dehydrins and its association with LFT in the segregating F₂ population and in the group of *R. maximum* plants differing in physiological age.

054

Changes in Membrane Fatty Acids in Cold-acclimated Turfgrass

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Three genotypes of seashore paspalum, 'PI 299042', 'Adalayd', and 'PI 509018-1' considered to be cold-sensitive, intermediately cold-tolerant and cold-tolerant, respectively, were analyzed to investigate the biochemical basis of cold tolerance. The cultivars were acclimated to 8/4 °C day/night temperatures and rhizomes nodes and crowns were harvested at 7-day intervals over the 4-week experiment. Total lipid was extracted from these tissues, and the fatty acids present in the lipid fraction were identified by gas chromatography. Palmitic acid, stearic acid, linoleic acid and linolenic acid were the major fatty acids present. In cold acclimated tissues, the level of palmitic acid and stearic acid did not change significantly during the treatment period. There was a decrease in the level of linoleic acid by the second week of cold treatment. The amount of linolenic acid increased significantly during the second week of cold treatment corresponding to the decrease in linoleic acid. The change in the amount was significantly greater in 'PI 509018-1' than in 'Adalayd' or 'PI 299042'. These results are similar to what was found for cultivars of bermudagrass that differ in their cold-tolerance phenotypes. Desaturases are enzymes involved in introducing the double bonds into the fatty acid chains. Research is underway to characterize and clone the genes encoding the Ω 3, Ω 6, and Ω 9 desaturases, which may have an important role in affecting the cold tolerance by altering the degree of membrane lipid fatty acid saturation.

055

Winter Survival Evaluation of 172 Groundcovers in Northern Illinois

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The winter hardiness of many groundcover cultivars in northern Illinois is not well-known. This study was designed to evaluate the survival of 172 plants used in the groundcover path at The Morton Arboretum. Once a month, from Sept. 1997 to Jan. 1998, the plants chosen for this study were visually evaluated and their vitality rated on a scale of 1 to 5 (1 = alive, 5 = dead). All nine cultivars of *Euonymus fortunei* remained virtually unchanged throughout the study period. Among six cultivars of *Hedera helix*, only 'Gold Heart' showed minor damage in November. Nine *Heuchera* were evaluated and all exhibited excellent resistance to cold temperatures. While all the *Pulmonarias* studied showed some cold damage by November, 'Bielefeld Pink', 'Little Blue', 'Roy Davidson', *Pulmonaria longifolia* var. *cevennensis*, and *Pulmonaria officinalis* 'Sissinghurst White' fared the best for the longest period of time. Five cultivars of *Pachysandra terminalis* were included in this study. None had significant damage until November, and then only rated a "2." Of the eight *Ajuga* evaluated, *Ajuga pyramidalis* 'Metallica Crispa', and *Ajuga reptans* 'Braunherz', 'Catlin's Giant', and 'Gaiety', exhibited the best cold resistance. Four *Polygonums* varied widely in their response to cold temperatures, but all showed signs of severe damage in November. *Polygonum* 'Border Jewel' exhibited the best tolerance, rating a "1" in October, but in November it was given a rating of "4." Their recovery in spring will be compared.

056

Timing and Duration of the Critical Period in Tomatoes for Sensitivity of Fruit and Seed Production to Heat Stress

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Peet et al. (*HortScience*, 1997) reported that the period of greatest sensitivity to heat stress for fruit and seed production in tomatoes (*Lycopersicon esculentum* Mill., line NC8288) was before pollen release. However the exact duration and timing of the sensitive period was not established. For the present study, 2 weeks before opening of the first flower, tomato plants grown at 28/22 °C or 32/26 °C were treated under the opposite temperature treatment for periods of 0, 5, 10, or 15 days. After this time they were returned to the initial temperature treatments constituting an imposition (32/26 °C) or relief (28/22 °C) of heat stress for varying periods before flower opening. All flowers were vibrated at anthesis and pedicels tagged to record date of pollination. Subsequently, tagged flowers (or pedicels, in the case of aborted flowers) were examined to determine if a fruit had set, and

if so, whether it contained seeds. For plants initially grown at low temperature, as the pre-anthesis period of exposure to heat stress increased, the amount of seeded fruit produced decreased. For plants initially grown at high temperatures, a pre-anthesis period of relief from heat stress of at least 10 days was required for production of any seeded fruit. Further, for an individual flower, that 10- to 15-day period of low temperatures had to occur during the developmental period starting at least 15 days before flower opening and ending no sooner than 5 days before flower opening.

057

Cowpea Seedling Response to Chilling Levels

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Controlled environment was used to simulate three chilling levels to assess differences in seedling growth of four cowpeas (*Vigna unguiculata* L. Walp), IT82E-18, IT82E-16, Pinkeye Purple Hull and MN13. Genotypes chilled at 14/10 °C, 15/10 °C, and 16/10 °C, (day/night) for 7 days after planting (DAP) did not differ in percent seedling emergence, which showed a maximum of 6%. At 14 DAP, genotypes differed in percent emergence at the 15/10 °C and 16/10 °C temperatures, with ranges of 34% to 51% and 61% to 86%, respectively. By 21 DAP, cowpeas at these two chilling levels had ranges of 57% to 90% and 79% to 94% emergence, respectively, and showed significant differences. At the two lower chilling regimes, the radicles failed to develop secondary roots and the seed coats remained attached to some of the primary leaves. These were generally chlorotic except for IT82E-16 at 15/10 °C. Genotypes at the highest chilling level developed secondary roots and green primary leaves, which were twice the size of those at 15/10 °C. When plants from the three chilling regimes were removed to a warm greenhouse, the leaves became green and secondary roots developed within a week. These results indicate that root development was more sensitive to the chilling temperatures than seedling emergence.

058

A Study on the Recovery Following Freeze–Thaw Injury in Onion and Chrysanthemum

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Onion (*Allium cepa* L. cv Sweet Sandwich) and Chrysanthemum (*Chrysanthemum grandiflora* 'Sunny Denise') tissues were used to investigate protein changes associated with recovery from freeze–thaw injury. Medium-sized onions were slowly frozen to either –4 or –9 °C, subsequently thawed, and divided in two halves. One half was used immediately for ion leakage (IL) measurements and total and microsomal protein extraction, whereas the other half was allowed to recover at 6 to 8 °C in the dark for 4 to 5 days. Chrysanthemum leaves were frozen to –3.75 °C, and allowed to recover first at 6 to 8 °C in the dark (1 d) and then under 12-h photoperiod at 18 °C (3–4 d). Results indicate a 1.4- and 2.5-fold higher IL, compared to control, from onion tissues frozen to –4 or –9 °C, respectively. IL in –4 °C-treated tissues was the same as respective control following recovery; however, it was further enhanced to 3.6-fold in –9 °C-treated samples. Chrysanthemum leaf tissue exhibited a 1.6-fold increase in ion leakage following injury, but completely recovered to control levels after 4 to 5 d. SDS-PAGE profiles revealed an absence of a 25-kDa microsomal protein in the injured onion tissues but, its up regulation during recovery only in reversibly injured tissues. Data also indicated an accumulation of 36-kDa soluble protein in chrysanthemum leaf tissues during recovery. Experiments are underway to further characterize these protein changes.

059

Changes in Non-structural Carbohydrates in Tulip Bulb Scales during Cold Treatment and Greenhouse Forcing

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The energy and carbon needs for early shoot growth in tulips are mainly provided by reserve carbohydrates in bulbs. The cold-treatment of bulbs before greenhouse forcing enhances the breakdown and remobilization of reserve carbohydrates in bulb scales, and is necessary for proper shoot growth and flowering

in tulips. Tulip bulbs are known to contain both starch and fructans as reserve carbohydrates. We evaluated several extraction solvents, including ethanol and distilled water, and several extraction temperatures to accurately determine the amounts of different types of non-structural carbohydrates in tulip bulb scales. Extraction with distilled water resulted in excessive solubilization of starch. For example, extraction at 70 °C solubilized more than 80% of starch to glucan polymers. On the other hand, 80% ethanol at 70 °C extracted all soluble sugars including fructans with no apparent solubilization of starch. The changes in non-structural carbohydrates in the outermost bulb scale of tulip (*Tulipa gesneriana* L. 'Frankfurt') during 12 weeks of cooling at 8.8 °C followed by 5 weeks of greenhouse forcing were determined. Starch was the major carbohydrate in bulb scales consisting of ≈70% of the dry weight at the beginning of cold treatment. Starch content per scale decreased slightly during cold treatment, but rapidly after transferring to greenhouse. Sucrose and soluble fructan content per scale increased during cold treatment, then decreased after transferring to greenhouse. Glucose content per scale remained fairly constant during cooling and greenhouse forcing, while fructose content increased in the greenhouse.

060

Enhancement of Floral Initiation and Bud Development by Chilling of Root Cuttings in Primocane-fruiting Blackberries

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In previous studies we found that primocane-fruiting blackberries (PFB) form flower buds soon after the plants start suckering from root cuttings collected in winter or early spring. Research was carried out to test if the same phenomenon holds true in summer-collected plant material. Root cuttings of A-1836, APF-13 and NC194 PFB were dug from the field on 31 July 1997 and stored in plastic bags at 2 °C for 32 days. On 1 Sept., freshly dug root cuttings along with the cold-treated ones were stuck in 3.8-L plastic pots, which were kept in a lath house for 4 weeks and then moved to a greenhouse under natural daylength. Significant differences occurred for plant emergence between chilled and non-chilled plants (16 days vs. 31 days, respectively). Transition from vegetative to floral phase was first observed in cold-treated A-1836 and APF-13 at five-node growth stage, with floral structures clearly evident in both selections at seven nodes of growth 45 days after planting. Chilled APF-13 and A-1836 started to bloom on 26 Nov. and 5 Dec., respectively. The first fruit of APF-13 were picked on 10 Jan. 1998. By this date, cold-treated NC194 and all non-cold-treated plants remained stunted with rosetted leaves, showing no signs of floral initiation. These findings present evidence that low-temperature exposure prior to shoot emergence greatly promotes flowering and fruiting in PFB. The results might have applicability in blackberry culture under greenhouse conditions.

061

Microscopic Examination of Chilling Injury Symptoms in Ethanol-treated Cucumber Seedling Roots

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Cucumber seedlings were germinated for 24 h at 25 °C and half were immersed in a 500 mM ethanol solution for 2 h. After rinsing, seedlings were chilled for 96 h at 2 °C. Control and ethanol-treated samples were taken for light and electron microscopy immediately before and after chilling, and after re-warming for 24 and 72 h. Preliminary experiments revealed visual chilling symptoms such as pinching of the root in a region just above the root tip. This region was excised under a microscope, fixed, and mounted for microscopic observations. The cortical cells of ethanol-treated seedlings before chilling appeared to be irregular in shape with irregular edges, and some epidermal damage was evident. Chilling caused much more epidermal damage in the control seedlings when compared to the ethanol-treated seedlings. After chilling, cortical cells in the control seedlings were observed to be irregularly shaped while those treated with ethanol had round cells. Upon re-warming, control seedlings exhibited increasing epidermal damage with broken cell walls, while ethanol-treated seedlings exhibited more differentiation in the stele.

42 POSTER SESSION 1G (Abstr. 062–064) Water Use and Application—Vegetable Crops

062

Plum Tomato Cultivar Evaluation Using Microirrigation

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Plum tomato (*Lycopersicon esculentum* Mill.) cultivars were evaluated in a full-bed mulch, microirrigation management system. Yield and horticultural characteristics were assessed for four entries, 'Marina', 'Spectrum 882', 'Supra', and 'Veronica', during Spring and Fall 1997. Harvested marketable fruit were separated by size into extra large, large, medium, and small categories. Spring: Total marketable yields from three harvests combining all fruit sizes ranged from 46.6 t·ha⁻¹ for 'Supra' to 57.1 t·ha⁻¹ for 'Veronica'. 'Veronica' produced significantly higher total yield than the other three cultivars. There were no significant differences among the cultivars in yield of extra large (range: 2.3 to 2.9 t·ha⁻¹) or large (range: 11.4 to 13.0 t·ha⁻¹) fruit. Only 'Veronica' (22.7 t·ha⁻¹) and 'Supra' (18.9 t·ha⁻¹) were significantly different from each other in the yield of medium fruit. 'Veronica' produced significantly more small fruit (19.2 t·ha⁻¹) than any other cultivar. Cull fruit yields ranged from 11.1 t·ha⁻¹ for 'Veronica' to 16.9 t·ha⁻¹ for 'Supra', which was significantly greater than the other cultivars. Fall: Total marketable yields from six harvests were not significantly different among the cultivars, ranging from 22.0 t·ha⁻¹ for 'Spectrum 882' to 31.4 t·ha⁻¹ for 'Marina'. Extra large fruit yields ranged from 2.0 t·ha⁻¹ for 'Supra' to 6.3 t·ha⁻¹ for 'Marina', the only cultivars significantly different from each other. There were no significant differences among the cultivars in yields of large (range: 7.9 to 13.8 t·ha⁻¹), medium (range: 8.7 to 13.8 t·ha⁻¹) or small fruit (range: 2.7 to 3.4 t·ha⁻¹). Cull fruit yields ranged from 37.2 t·ha⁻¹ for 'Supra' to 47.4 t·ha⁻¹ for 'Veronica'. Cuticle cracking (rain check), black shoulder and nipple-tipped blossom ends were the primary defects in the fall. 'Marina' and 'Veronica' produced significantly more cull fruit than either 'Supra' or 'Spectrum 882'.

063

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 (22 m in static level) and it is important to use of this resource rationally. During 1997, an experiment of drip irrigation in asparagus (first year planted) was conducted. Three treatments were applied: 100%, 133%, and 166% of the evaporation from a pan evaporation type A. The crop coefficient (K_c) applied was 60%. The results of the statistical analysis indicated that the best treatment was 166% (246.13 cm of total water applied) with a height of plant of 1.17 m, and the lowest height of plant was for the 100% (0.87 m) with 121.97 cm of total water applied.

064

WITHDRAWN

42 POSTER SESSION 1H (Abstr. 065–074) Crop Physiology: Chemical/Developmental/Metabolic—Cross-commodity

065

Distribution of Seasonally Expressed Storage Proteins in Different-aged Shoots and Roots of 'Loring' Peach

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During autumnal leaf senescence, leaf nitrogen is translocated to other sites for storage, especially bark tissues. By definition, proteins that accumulate in large amounts in winter and are absent in summer are called storage proteins. Previously, we have characterized three proteins in peach bark tissues that fall into this category. Little is known, however, about the distribution of these proteins in different-aged tissues or whether they have any function other than to act as a nitrogen reserve. The present study characterizes the seasonal distribution of a 60-, 19-, and 16-kDa protein in bark tissues of current-year, 1-year-old, scaffold, and trunk bark, and 4- to 5-year-old roots of 'Loring' peach. Verification of protein identity was based on molecular mass and reaction with antibodies directed against each specific protein. Distribution of the proteins was variable. The greatest amount of all three proteins was present in current-year and 1-year-old shoots. These tissues also showed the greatest seasonal variation in the amount of protein present. The 16-kDa protein was present only in the youngest shoots, whereas the 19-kDa was present in all tissues examined. The 60-kDa protein was absent in root tissue. The 60-kDa protein has been identified as a dehydrin, and the 16-kDa protein appears to be related to defensins. The identity of the 19-kDa protein has not been confirmed. The amino acid composition of the three proteins will be presented and the implications of these results on management practices will be discussed.

066

Endogenous Rhythm in Flowers of Stone Fruits

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It is known that the success of pollination of entomogam, autosterile stone fruits depends on attractiveness of flowers, pollen, and nectar production. In addition to this a complete harmony is necessary between the pollen donor and receiver in the volume of intrafloral secretion, chemical composition, and timing of appearance of attractants. Our investigation shows that the daily production in stone fruits follows a set pattern. The 4 x 6-h rhythm (secretion four times, 6 h apart per day) usually indicates homogamy, whereas a 2 x 12 periodicity indicates dichogamy. Successful pollination is unlikely when endogen rhythm of two cultivars is asynchronized.

067

Floral Scent Production in *Antirrhinum majus*

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Despite the economic importance of floral scent for plant reproduction, little is known about the molecular mechanisms of floral scent production. Floral scent is often a complex mixture of low-molecular-weight compounds that are mainly distributed within three groups: fatty acid derivatives, benzenoids, and isoprenoids. Esters of such compounds are the most widespread type. Headspace analysis in combination with gas chromatography and mass spectrometry of volatiles emitted from snapdragon flowers revealed that methyl benzoate is one of the major components of the 'Maryland True Pink' genotype. The activity of novel enzyme S-adenosyl-L-methionine:benzoic acid carboxyl methyltransferase (BAMT), which catalyzes the methyl esterification of benzoic acid, was analyzed in different floral tissues and at different stages of flower development. It has been found that BAMT activity is highest in petals, both upper and lower lobes, and very low or absent in other floral tissues and leaves. No detectable BAMT activity was found in flower buds 1 day before flower opening. During the lifespan of the flower the level of BAMT activity in petal tissue increases gradually and remains high in old flowers.

068

A Leaf Bud Development Scale for Rabbiteye Blueberry

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Crop vegetative and reproductive development are frequently divided into stages to describe progression of development. Such a description is useful in denoting developmental differences between cultivars, for making crop management decisions based on growth stages, and for clear communication among

individuals concerned with research, management, and production of the crop. We have developed such a scale for leaf bud development in rabbiteye blueberry (*Vaccinium ashei* Reade). Our scale has six stages briefly described as follows: 1) dormant bud; 2) early green tip; 3) late green tip; 4) unfolding stage; 5) mouse-ear stage; 6) fully opened bud. Categorizing buds in this manner has proven useful in comparing rates of leaf development between cultivars and in response to winter chilling. The stages appear to be relevant to highbush blueberries (*V. corymbosum*) as well.

069

Clone and Growth Season Effects on Seven Carbohydrate-related Components and Their Correlation in Sweetpotato

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Approximately 50% of the world's total sweetpotato output is used for producing starch or starch-derived products and for animal feeding. Knowledge of cultivar and environmental effects on carbohydrate-related components and the correlation among these components is essential for improving the raw products utilization and providing an expanded market for sweetpotato. The objective of this study was to investigate the variation of amylose content and β -amylase activity as well as their correlation with other starch-related components. Dry matter, starch, total sugar, amylose and phosphate content, β -amylase activity, and raw starch digestibility were evaluated for 20 advanced selections in 2 years. Significant clone variation was detected for all seven components. Significant growth season effects were found for amylose and sugar content, β -amylase activity, and starch digestibility. β -amylase activity has a negative correlation with starch ($r = -0.57$, $P \leq 0.001$) and dry matter ($r = -0.39$, $P \leq 0.05$). Starch digestibility has a negative correlation with amylose ($r = -0.37$, $P \leq 0.05$) and phosphate content ($r = -0.35$, $P \leq 0.05$).

070

Jasmonic Acid and Environments Increase Steroidal Glycoalkaloid Biosynthesis in *Solanum chacoense*

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Steroidal glycoalkaloids in *Solanum chacoense* have been found to deter feeding by herbivores, especially to Colorado potato beetle. The steroidal glycoalkaloids of *S. chacoense* include solanine (chaconine), leptinines, and leptines, which yield solanidine, leptinidine, and acetylleptinidine, respectively, upon acid hydrolysis. To understand the regulation of their biosynthesis, tissue culture plants were grown on MS media containing jasmonic acid, methyl jasmonate, or arachidonic acid at different levels. After 1 month in culture, 100 μ M jasmonic acid stimulated solanidine, leptinidine, and acetylleptinidine accumulation 3- to 10-fold compared to control. Methyl jasmonate at 100 μ M also induced solanidine accumulation, but not leptinidine and acetylleptinidine. Arachidonic acid had no effect on solanidine, leptinidine, and acetylleptinidine levels. Furthermore, leptinidine and acetylleptinidine levels increased 5-fold and 100-fold, respectively, after plants were transferred from culture in vitro to soil; meanwhile, solanidine level decreased slightly. Solanidine, leptinidine and acetylleptinidine from plants in vitro showed no changes during the same period. Our results indicated that jasmonic acid and environmental factors play important roles in the biosynthesis of steroidal glycoalkaloids in *S. chacoense*.

071

Effect of Antitranspirant and Fertilization on Flowering, Fruiting, and Biomass Production in 'Early Girl' Tomato Plants

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Seedling plugs of 'Early Girl' tomato plants (*Lycopersicon esculentum* Mill.) were potted in peatmoss and perlite (60:40% by volume) medium, fertilized with 8, 16, 24, or 32 g NutriCote Total controlled-release fertilizer (type 100, 13N-5.67P-10.79K plus micronutrients) per pot (2.81 L), and treated with 0%, 2.5%, 5%, or 7.5% antitranspirant GLK-8924 solution, at the four true-leaf stage. Plants were tipped at the second inflorescence and laterals were removed upon

emergence. Flowering of both clusters were advanced by higher fertilization rates and depressed by GLK-8924. Increasing rates of fertilization increased flower and fruit number of the lower cluster and fruit set of upper cluster. GLK-8924 had no effect on flower number, fruit number, and fruit set. Fertilization increased the biomass production of all plant parts while GLK-8924 reduced the biomass production of leaves and fruit only. Root and stem biomass was not influenced by GLK-8924. The effect of GLK-8924 on fruit dry weight was dependent on the position of the cluster and GLK-8924 concentration. Fertilization did not interact with GLK-8924 to influence flowering, fruiting, and biomass production.

072

Regional Differences in Plant Development, Water Relations, and Chloroplast DNA of Hard Maples

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Principal component analysis of foliar traits of hard maples (*Acer saccharum* Marsh. and *Acer nigrum* Michx. f.) near 43°N latitude clustered data into two populations composed of trees from different geographical regions. Seedlings from these two regions, and a third, geographically intermediate region, were grown in a greenhouse for 2 years with two irrigation frequencies to assess regional differences in plant development and water relations. Leaves from the most western region (west of 93°W longitude) had the highest specific mass (5.97 mg/cm²), trichome frequency (531/cm²), and stomate frequency (628/cm²). Across regions, plants irrigated frequently had more stomates (596/cm²) than plants irrigated sparsely (483/cm²). Traits similar across regions but higher with frequent irrigation included surface area and mass of lamina, shoot-to-root ratio, the ratio of lamina area to stem xylem diameter, and leaf water potential. Sparse irrigation caused a comparatively large decrease in stomatal conductance of plants from the most western region, and pressure-volume analysis showed no regional or irrigation effects on leaf osmotic potential at full turgor. Identical banding patterns resulted when *Hinf* I digested the PCR-amplified *trnL-trnF* intergenic spacer region of chloroplast DNA from each region; work with the *rpl16* and *ndhA* introns is proceeding. Trichome frequency on abaxial leaf surfaces, which differs regionally both in nature and in controlled environments, is the most consistent character we have measured for discerning populations.

073

Quantitative Seasonal Changes in Gross Turfgrass Morphometry

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Photographs of turfgrass canopies were taken throughout Spring, Summer, and Fall 1997 at a height of 1.3 m using a 28-mm lens and film sensitive to either visible or infrared light. The species evaluated were warm-season Bermudagrass, buffalograss, zoysiagrass, and cool-season tall fescue. Color spectra of digitized photographs were obtained by first separating the hue, saturation, and intensity components of the color photo into separate 8-bit (256 gray levels) files. Calculations were then made on the basis of those color components. The infrared photos were scanned as 8-bit files without conversion. Greenup was indicated by a decrease in the frequency of hues between 0 and 50° (reds, browns, and yellows) and an increase in the frequency of hues between 50 and 100° (green and yellow-green). It is well-known that canopy reflectance in the green wavelengths is primarily a function of chlorophyll density, whereas reflectance of near-infrared radiation is indicative more of cell structure. More near-infrared radiation is reflected from leaf surfaces than is green radiation, and less infrared is absorbed by internal leaf structures than is visible radiation. Thus, it is possible to approximate canopy leaf area ratios by using both visible and near-infrared photographic measurements. Quantitative changes in visible and near-infrared canopy reflectances, leaf area ratios, and other morphometric parameters will be presented as a function of time of the year and species. The results demonstrate the utility of using this relatively inexpensive procedure to obtain quantitative measurements as a substitute for, or in conjunction with, subjective visual ratings of turfgrass plots.

074

Dormancy-breaking Studies on *Echinacea angustifolia*

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Echinacea is a medicinal plant native to North America. It was used extensively by native Americans in the treatment of their ailments. It is presently one of the

most popular medicinal plants in the United States. Its popularity has created a large market demand for the roots and foliage of the plant. The gathering of echinacea from the wild is leading to the reduction of native populations and the destruction of its genetic diversity. Cultivation of medicinal echinaceas is hindered by a low seed germination. Dormancy breaking studies were done on freshly harvested seeds of *Echinacea angustifolia*. Seed lots were placed under light at a constant temperature of 25 °C and at alternate temperatures of 25/15 °C for 14/10 h, respectively. Germination was more rapid and uniform and percent germination higher at 25 °C than at 25/15 °C. Seed tap-water soaking, dry heating, and sharp heating alteration did not increase germination. The application of 1.0 mM ethephon (2-chloroethylphosphoric acid) increased seed germination to 94% at 25 °C and 86% at 25/15 °C. Untreated seeds gave 65% germination at 25 °C and 11% at 25/15 °C. The application of 2500 mg·L⁻¹ and 3500 mg·L⁻¹ of GA to dry seeds and 2500 mg·L⁻¹ to seeds that have been soaked under tap water and then dried increased germination to 82%, 83%, and 83% at 25 °C and 64%, 78%, and 64% at 25/15 °C, respectively.

42 POSTER SESSION 1I (Abstr. 075–078) Postharvest Physiology – Tropical Fruits

075

Response of the Mamey Sapote (*Pouteria sapota* L.) Fruit to Storage

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The mamey sapote is a fruit highly appreciated by its sweet flavor. Although this crop has been cultivated in tropical America for several centuries, there is still little horticultural information about it. The fruit is very perishable and postharvest losses are usually large. The objective was to evaluate the postharvest changes in fruit quality under storage conditions. Fruit grown in Morelos, Mexico, were harvested when there was a color change from green to pink in the tissue just below the fruit cortex. Fruit were stored at 10 °C or kept at 20 °C (65% RH) or ambient temperature (Mean daily temperature = 27 °C) for 24 days or until fruit deteriorated. After storage at 10 °C, fruit were kept at 20 °C to allow for fruit ripening. Fruit kept at 27 °C ripened 3 days after harvest, while those at 20 °C ripened 5 days after harvest. Fruit at 10 °C showed little physical or chemical changes over the storage period. Ripening included fruit softening, a change in pulp color from a yellow or pale pink to an intense pink color, and an increase in SSC. No change in fruit cortex color was detected as ripening progressed. Ripe fruit showed a 30% to 35% of SSC, and a firmness (resistance to penetration) of 7 N. In overripe fruit, pulp color turned brown. Fruit stored at 10 °C and then ripened at 20 °C showed an irregular ripening, with portions of the fruit with a high firmness and others with a low firmness. This irregular ripening was more severe on fruit stored at 10 °C for 14 days than those stored for 7 days. This disorder was probably a result of chilling injury.

076

Fresh-cut Mango Fruit Slices

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Preparation and handling procedures for fresh-cut mango slices were developed using 'Tommy Atkins', 'Haden', and 'Palmer' mangoes. Fruit with yellow flesh color (no green color remaining) were optimum maturity for fresh-cut in terms of maintenance of acceptable appearance, texture, and taste; riper fruit developed flesh breakdown and more browning. Postharvest life of fresh-cut mango at 5 °C was 8 to 10 d with no evidence of chilling injury and was limited by flesh browning and loss of firmness. Respiration rates ranged from 32 to 40 mg CO₂/kg per hr and ethylene production was typically $\pm 0.1 \mu\text{l}\cdot\text{kg}^{-1}\cdot\text{hr}^{-1}$. The SSC changed little during storage, while pH varied from 3.5 to 4.8 and TA typically declined by 30% to 40%. Peeling to a depth of at least 2 mm and trimming flesh near the stem scar was necessary to minimize browning. Imported fruit that had been heat-treated for insect quarantine showed more severe browning than Florida fruit that had not been heat-treated. Preparation in aseptic conditions and dipping fruit in a 100

ppm NaOCl solution at pH 7 before and after peeling protected against decay during storage but dipping in chlorine after slicing without removal of excess liquid resulted in flesh translucency and breakdown. Dipping in 1% CaCl₂ solution had no effect on flesh firmness (Instron) or browning. Storage in an unvented plastic clamshell container, which developed an atmosphere of 2.25% CO₂ plus 19% O₂, did not improve shelf life, but a MA of 10% CO₂ plus 10% O₂ was subjectively judged to slow browning and softening and resulted in no off flavor compared to air storage.

077

Quality of 'Solo' Papaya after Irradiation Treatment and Ripening

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Papaya (*Carica papaya* L.) imported into the United States must be certified free of infestation by unwanted pests. Irradiation has been suggested as a potential quarantine treatment for papaya. A study was conducted to characterize fruit quality and condition at two stages of maturity and exposure to irradiation treatment. 'Solo' papaya grown in Belize was transported in refrigerated sea van containers to Florida. Fruit showing no yellow color or one-quarter yellow color were irradiated at 0.6 kGy, held at 25 °C until ripe, and evaluated for quality and condition attributes. Green peel papaya treated with irradiation developed peel injury and had uneven ripening of pulp tissue following storage. Development of peel or pulp color was not affected by irradiation. Fruit should show one-quarter yellow peel color to avoid irradiation-induced peel damage. Irradiation may be a viable quarantine treatment for papaya that can be applied to fruit at the source of offshore production or on arrival at a facility in the United States.

078

Influence of Storage Period on the Postharvest Characteristics of Five Mango (*Mangifera indica* L.) Cultivars

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Five mangos cultivars (*Mangifera indica* L., 'Palmer', 'Keitt', 'Spring Field', 'Kent', and 'Anderson') were harvested at the preclimacteric stage. Fruits were selected for study that were uniform and free of visual defects and stored for 18 days at 10 °C, 90% to 95% RH. Fruits were evaluated every 3 days for pulp and peel color, total soluble solids, titratable acidity, ascorbic acid content, and total and reducing sugars. Pulp and peel color parameters (lightness, hue, and chroma) were significantly different among cultivars. The soluble solids content, ascorbic acid, and starch content changed significantly during storage and were significantly different among cultivars. Total and reducing sugars content did not change significantly after 10 days of storage. Results of this study indicated that these five mango cultivars have good storage potential.

42 POSTER SESSION 1J (Abstr. 079–087) Postharvest Physiology & Food Science— Vegetable Crops

079

'Betasweet', Carrot Designed for Flavor, Nutrition, and Health

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'BetaSweet' is a new "designer" carrot that was conceived as a research project with the objective to create a new high-quality vegetable with unique characteristics. The gene responsible for purple or maroon color in carrots is a natural one and has been around for many years. Carrot breeders have discarded carrots that occasionally segregated to this color because orange has been the preferred traditional color. In 1989, three carrots grown from Brazilian seed were observed to have a blotchy maroon color mixed with the normal orange. Within two generations of breeding effort, I had obtained a few carrot roots with near-complete maroon exterior color and orange interior. The contrast of orange and

maroon was very attractive in carrots cut as coins or sticks. The maroon and orange color would serve as the perfect way to identify and promote this new variety. Several additional generations were required using extensive laboratory testing for low terpenoids (strong carrot flavors), high sugars, high carotene, and crispy texture. Thousands of carrot roots were analyzed and selected for those qualities and for the dark maroon exterior and orange interior colors. The few best for those characteristics were intercrossed, and re-selected for their adaptation when grown under Texas climatic conditions.

080

Carotenoid, Tocopherol, and Ascorbate Variability in Cruciferous Vegetables

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Antioxidants have been associated with reduced risk of cardiovascular disease and several types of cancer. Recent studies indicate that cruciferous vegetables contain high levels of these antioxidants. We assayed the edible portions of 52 broccoli and 13 cabbage, kale, cauliflower, and Brussels sprouts genotypes to determine variability of α -carotene, β -carotene, α -tocopherol, γ -tocopherol, and ascorbate within and between varieties of *Brassica oleracea*. Emphasis was placed on broccoli due to its economic importance and consumer preference. Samples of each genotype in replicated trials were harvested at fresh-market stage, frozen immediately in liquid nitrogen, and placed in -80°C . HPLC with an amine column was used to measure ascorbate in fresh, frozen samples. Tissue for carotenoid and tocopherol analysis was freeze-dried prior to extraction. Carotenoid and tocopherol concentrations were simultaneously measured using a reverse-phase HPLC system developed in our laboratory. Results indicate that there is substantial variability both within and between varieties. Kale had the highest levels of these compounds, followed by broccoli and Brussels Sprouts with intermediate levels, then by cabbage and cauliflower which were relatively poor sources. Based on dry weight, broccoli heads ranged (in mg/g) from 0–2.9, 23–94, 24–222, and 2–5 for α -carotene, β -carotene, α -tocopherol, and γ -tocopherol, respectively. The range of ascorbate was 54–120 mg/100 g fresh weight. These results contradict the general perception that all broccoli lines are equally beneficial in potential disease prevention. The information gained from this study can be used to help consumers select foods that promote a healthy lifestyle and in breeding programs to develop new germplasm that will enhance the antioxidant potential of our food supply.

081

Methyl Jasmonate Inhibits Postharvest Sprouting of Radishes

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Treatment of topped radishes (*Raphanus sativus* L., cv. Cherry Belle) with methyl jasmonate was effective in inhibiting postharvest sprouting of new leaves and the growth of roots. Radishes were trimmed to 10-mm tops and dipped in various methyl jasmonate suspensions for 3 min. After storage at 15°C for 7 days, the growths of new leaves were 26, 22, 7, 3, and 1 mm in 0, 10^{-5} , 10^{-4} , 10^{-3} , or 2×10^{-3} M methyl jasmonate-treated radishes, respectively. The lengths of root growth were also reduced by methyl jasmonate particularly at higher concentrations. These treatments also substantially reduced weight loss possibly as a secondary effect. Fumigation with methyl jasmonate vapor in enclosed containers was also effective in inhibiting the sprouting of leaves and root growth, but to a lesser extent than dipping treatments. Radishes stored at 0°C did not show any new growth of leaves or roots, and therefore were not affected by the methyl jasmonate treatments.

082

Factors Affecting Seed Coat Yellowing of Pinto Beans

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The pinto bean breeding line 94-4 (*Phaseolus vulgaris* L.) showed seed coat yellowing in on-farm field trials in Nebraska in 1996. After reviewing weather data, sprinkler irrigation appeared to be one of the cultural factors involved with increase in seed coat yellowing. Cultural conditions were again investigated in

1997 in on-farm trials. In one test half of the NE 94-4 plants were cut and combined promptly while the other half of the cut plants were left on the ground, rained upon, and combined later. Seed from the pods of former and latter treatments were compared for degree of seed coat yellowing. Yellowing was recorded visually by determining percentage of the yellow area on a bean seed. The seed from the pods of the cut wetted plants showed more discoloration than seed from the plants that were not rained on. In another experiment two or four samples (40 g each) were taken from each of seven cultivars as well as NE 94-4 to determine degree of yellow discoloration of seed. The percent seed coat yellowing of the varieties/line was as follows: 'Apache' 12.5%, 'Bill Z' 14.9%, 'Buckskin' 20.7%, 'Chase' 9.2%, 'NE-94-4' 54.1%, '179' 48%, 'Vision' 35.5%, 'Winchester' 10%. Results of pigment extraction and simulated irrigation experiments will be presented in order to better explain the cause of pinto seed coat yellowing.

083

Changes in Sensory Quality of Minimally Processed Cantaloupe Stored in Controlled Atmospheres

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The effects of a range of controlled atmospheres (CA) on sensory quality and acetaldehyde and ethanol concentrations in minimally processed cantaloupe melon were studied. Cylinders (1.8 diam x 3.5–4.0 cm) were prepared from cantaloupe melons cv. Durango harvested at commercial maturity. Pieces were stored in air or six CA (1.5 and 3% O_2 , air + 7.5 or 15% CO_2 , and 3% O_2 + 7.5 or 15% CO_2) for 15 days at 5°C . After 9 days of storage, the pieces stored at 5°C were firm, had high chroma values and visual quality and aroma scores, and low decay and off-odor scores. Elevated CO_2 concentrations reduced microbial counts and the combination of CO_2 with 3% O_2 provided additional control. All CA treatments with CO_2 maintained visual quality above the limits of salability at 15 days, while quality of air-stored pieces was poor. The same CA also reduced loss of typical cantaloupe aroma and development of off-odors. Acetaldehyde concentrations increased after 9 days, but then declined. Ethanol levels increased linearly with time in pieces stored in low O_2 alone or with CO_2 . Pieces stored in CA had higher soluble solids than those stored in air. Pieces prepared with a sharp borer maintained visual quality scores longer than those prepared with a blunt borer due to the development of surface translucency and color changes. The sharpness of the borers did not affect the development of decay nor the loss of characteristic aroma.

084

Low Temperatures and High CO_2 Atmospheres Best Maintain the Quality of Fresh-cut Jicama (*Pachyrhizus erosus*)

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The jicama is a chilling-sensitive specialty root vegetable used fresh for its crisp sweet-starchy pulp. Our objective was to evaluate a range of storage temperatures and controlled atmospheres potentially useful to preserve the quality of minimally processed jicama. Jicama root pulp was cut into 1.8 x 4-cm cylinders, washed in chlorinated water, drained, and stored in glass containers at a range of temperatures from 0 to 15°C in air, or at 5 and 10°C in controlled atmospheres (0.3, 3, and 21% O_2 with 0, 5%, 10%, or 20% CO_2). Pieces were evaluated after 0, 4, 8, 12, or 16 days for visual quality, color, texture, and composition (soluble solids, ethanol, acetaldehyde). Total aerobic plate counts were determined on samples from some atmospheres. At temperatures $>5^{\circ}\text{C}$, browning was the most significant cause of quality loss. High CO_2 atmospheres retarded the development of brown discoloration at 10°C . During storage at 0 or 5°C in air, quality loss was principally due to yeast and bacterial growth. The 10% CO_2 atmospheres helped maintain the white color and crisp texture of the pieces and retarded microbial growth. Atmospheres with 20% CO_2 damaged jicama stored longer than 8 days. Atmospheres of 3% O_2 or air with 10% CO_2 resulted in acetaldehyde and ethanol concentrations 4 and >10 times those of air-stored pieces after 8 days at 5°C . Although the jicama root is chilling-sensitive, our results demonstrate that the quality of the minimally processed product is best maintained with low temperatures in combination with high CO_2 atmospheres.

085

Changes in Lipid Peroxidation and Antioxidant Status in Ripening Muskmelon (*Cucumis melo* var. *reticulatus*) Fruit

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Muskmelons are perishable fleshy fruits with a shelf life of less than 14 days. This short timespan is a serious limitation to marketing of the fruits and reduces the profitability of the crop. Variation exists within and between melon types for postharvest storage ability, indicating a breeding program aimed at introducing longer storage times into muskmelon might be successful. However, there is a fundamental lack of knowledge of the underlying physiological processes that determine longer storage ability. Disruption of cellular membranes appears to be a persistent feature of plant senescence. Melon fruit tissues show a progressive decrease of membrane integrity, as measured by membrane permeability, as the fruit matures. Loss of membrane integrity may hasten tissue breakdown due to a loss of cellular compartmentalization and altered expression of membrane-bound enzymes. This project examines melon fruit during their development and postharvest storage. Fruit were collected at 20, 30, and 40 days post-anthesis, and after 10 days of storage. Fruit tissue was examined for evidence of lipid peroxidation which may contribute to the loss of membrane integrity. In addition status of the key antioxidants glutathione (GSH), ascorbate, and vitamin E was assayed to determine the possible breakdown sight of the cellular protection system. This information may be directly useful in providing selection criteria for a breeding program aimed at increasing muskmelon postharvest storage life.

086

Curing Influences Sugar Metabolizing Enzyme Activity in Sweetpotato

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Sweetpotato roots ('Beauregard', 'Hernandez', and LSU breeding line 9496) were cured (30 °C and 90% RH) for 10 days immediately after harvest to determine the effect of curing on several sugar-metabolizing enzymes. Free sugars and activities of invertase, sucrose synthase (SS), and sucrose phosphate synthetase (SPS) were assayed. Total sugars for the three genotypes ranged from 132.5 to 177.9 mg sugar/g DW at harvest, and from 162.3 to 204.3 mg sugar/g DW after curing. Enzyme activity at harvest averaged over the three genotypes ranged from: 154 to 251 mol sucrose DW/h for invertase; 18.6 to 23.1 mol sucrose DW/h for SS, and 7.4 to 15.7 mol sucrose DW/hr for SPS. Enzyme activity after curing averaged over the three genotypes ranged from: 251 to 288 mol sucrose DW/h for invertase; 20.3 to 25.8 mol sucrose DW/h for SS, and 11.3 to 17.3 mol sucrose DW/h for SPS. The increase in invertase activity during curing was highest in 'Hernandez' and lowest in the breeding line 9496. The increase in invertase activity correlated to the increase in reducing sugar content for 'Hernandez' and 'Beauregard'. Curing also shifted the pH optima of invertase in 'Hernandez' from pH 5.2 to 7.6.

087

Water-absorbent Packet Beneficial to Fresh-cut Honeydews

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Fluid accumulation and moisture condensation were of a concern on the quality of fresh-cut honeydews in polymeric film-wrapped containers; thus, the effect of a water-absorbent packet in the container was evaluated. Honeydew cubes were placed in plastic trays with and without water-absorbent packet and sealed with polymeric film, which was either left intact or perforated with a needle. The samples were stored at 5 °C and visual quality score, color, texture (shear force) soluble solids, pH, and microbial count were determined after 4, 8, and 14 days of storage. Honeydew cubes in perforated film packages without the absorbent became unsalable on day 4, while those with a water-absorbent packet had salable quality on day 8 and were unsalable by day 14. Main detriment in salability was development of water-soaked lesions and deteriorated condition. There were less water-soaked lesions in cubes held in sealed film packages with or without an absorbent packet than in perforated film packages with an absorbent packet. Tissue breakdown occurred earlier in sealed packages without an absorbent packet than in packages with an absorbent packet. The absorbent packet retarded the decreasing Hunter 'L' value, increasing hue angle (a/b), softening (shear force), and increasing pH. Sealed film retarded changes in color and in mesophilic bacteria, yeast, and

mold population.. The oxygen in sealed packages decreased to 10% and carbon dioxide increased to 6% by day 14, which was not harmful to the tissue. These results indicate that the a water-absorbent packet was helpful in maintaining quality of honeydew cubes held in containers with sealed or perforated film.

42 POSTER SESSION 1K (Abstr. 088–094) Crop Production—Small Fruit/Viticulture

088

Protected Culture Systems for Strawberry Production

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Strawberry plants (cvs. Camarosa, Chandler, Sweet Charlie, Primetime, Jewel, and Tribute) were grown in soilless culture systems in a greenhouse from October to May. Fresh-dug and runner-tip Aplug® plants were transplanted into two systems: vertically stacked pots (24 plants/m²) containing perlite and horizontal nutrient film technique troughs (13 plants/m²). Plants were fertigated continuously with recirculating nutrient solution. In a 7-month production cycle, the plug plants bloomed earlier and produced more fruit during the first month of harvest (December) than the fresh-dug plants. Higher yields from plug plants were a result of more fruit numbers and not larger fruit size. Fruit production averaged 6.0 and 3.5 kg/m² in the trough and pot systems, respectively. The vertical growing system allows greater plant densities, but light intensity reaching the plants in the lower sections of the tower can be less than 20% of levels measured at the top. Establishment costs of protected culture systems are higher, but production is earlier and labor costs are typically reduced. Greenhouse hydroponic culture systems could extend the winter strawberry production to more northern locations.

089

Strawberry Waiting-bed Plants: A Valid Alternative to Increase Early and Total Yields in Subtropical Regions

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Strawberry (*Fragaria xananassa* Duch.) production in subtropical areas is characterized by a low late-fall and early winter fruit yield, a time when the value of the crop is the highest of the season. Under this context, the objective of the present study was to evaluate the feasibility of waiting-bed plants for late fall and early winter production in order to increase early and total fruit yields in the Argentine sub-tropic. Plants of the cultivar 'Chandler' produced in a waiting-bed (WB), at high-latitude (HL), high-altitude (HA), or low-altitude (LA) were compared at two locations in Tucuman, NW Argentina: Famailla (1995, experiment 1; 1996, experiment 2) and Lules (1995, experiment 3). Total production from WB plants was 41% higher than from HA plants in experiment 1. Total production from WB plants was 83 % and 53 % greater than from HL plants and LA plants, respectively, in experiment 2. Early season fruit production was greater in WB (241%) than HL plants in experiment 2. In experiment 3, early fruit production from WB plants was greater than HL, HA, and LA, by 573, 177, and 158%, respectively. The number of marketable fruit from WB plants was larger than in the other treatments (139-231%). WB percentages of marketable fruit were above 90%. The results suggest that WB plants could be considered as an alternative to HL, HA, and LA plants to improve strawberry production and yield distribution in South American subtropical regions.

090

Weed Seed Banks in Established Strawberry Fields

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Weed control in strawberries, either in a new planting or one that is established, is a major source of problems for growers in Minnesota. To control weeds, growers need to know which weeds are a problem, which weeds are deleterious, and which weeds have the potential to become a problem. Weeds present, soil type, and weed seed bank information are needed in order to predict potential weed problems. With different weed control practices applied between and within the rows, we

assumed weed seed bank populations would vary. In addition, we were interested in seeing if the seed banks differed between soil types and individual farmer's cultural practices. Soil samples were collected from 13 commercial strawberry fields located around the Twin Cities metro area. In 1996, samples were taken after renovation and before mulch was applied. In 1997, they were taken after mulch was removed and prior to renovation. The soil samples for each date, treatment, and farm were dried, and organic matter was separated from inorganic. The weed seeds were removed from the remaining organic matter, identified and counted. Soil types and cultural practices were used to compare the differences among the farms.

091

Influence of Cover Crop on Soil Quality in Strawberry

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Traditional cover crops, such as perennial ryegrass (*Lolium perenne*), and sorghum-sudan grass (*Sorghum sudanense*), commonly are used in rotation with strawberry in the midwestern United States to improve soil quality and suppress weeds. The objective of the field study was to investigate the effects of various cover crops on soil quality and weed populations. The experiment was established in 1996 at the Iowa State Univ. Horticulture Station, Ames, in plots that previously were planted continuously in strawberry for 10 years. Nine treatments were arranged in a randomized complete-block design with three replications. Treatments included cover crops of Indian grass (*Sorghastrum avenaceum*), switch grass (*Panicum virgatum*), big bluestem (*Andropogon gerardii*), black-eyed susan (*Rudbeckia hirta*), marigold (*Tagetes erecta* 'Crackerjack'), sorghum-sudan grass, perennial ryegrass, strawberry (*Fragaria xananassa* 'Honeoye'), and bare soil (control). Of the prairie plants, *Andropogon gerardii* was the most difficult to establish and thus had the highest percentage weed cover. Macroaggregate mass of the soil at 0- to 15-cm depth was least in the bare-soil treatment and in the other annual-plant treatment, *Tagetes erecta* 'Crackerjack'.

092

Effect of Root-zone Temperature on Strawberry Growth and Development

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Root-zone temperature (RZT) effects were studied to determine physiological changes on whole-plant and microscopic levels of strawberry (*Fragaria xananassa*) growth and development. A greenhouse experiment was conducted in 1997 with 'Tristar' day-neutral strawberry using a randomized complete-block design with three RZT treatments (23, 29, and 35 °C) and four replications. The total number of flowers was less in plants subjected to 35 °C. Total weight of fruit yield was highest at 29 °C and least at 23 °C, due possibly to later fruit development. Fresh weight was highest in plants grown at 23 and 29 °C. Dry weight analysis showed that root and leaf growth were inhibited at 35 °C. Throughout the duration of the experiment, transpiration rates were lower in plants subjected to 35 °C. In general, plants grown under RZT of 29 °C had more optimal vegetative and reproductive growth than those grown under 23 and 35 °C.

093

Effect of Inoculum Level on Response of Strawberry Fruit to Anthracnose Fruit Rot

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In North Carolina, anthracnose fruit rot of strawberry (*Fragaria x ananassa* Duch.) is caused by the fungus *Colletotrichum acutatum* Simmonds. Little is known about the mechanisms of field resistance of fruits to anthracnose. It appears that resistance of various plant parts including runners, crowns, and foliage is not always correlated with resistance of fruit. Resistance of fruit may be simply overwhelmed by excessive fungal conidia. Is there a threshold level of inoculum and does this threshold vary for fruit of different cultivars? The objective of this study was to determine the effect of inoculum level on the response of seven strawberry cultivars/breeding lines to a single *C. acutatum* (CA-1) isolate. The experimental design was a split-plot with five levels of inoculum (0, 1 x 10³, 1 x 10⁴, 1 x 10⁵, and 1x10⁶ conidia/ml) as the whole plot and seven cultivars/breeding lines ('Apollo', 'Chandler', 'Camerosa', 'Pelican', 'Sweet Charley', NCH 95-173, and NCR 94-08) as the subplots with three replicates. The experiment was conducted

in a growth chamber at the Southeastern Plant Environment Laboratory at North Carolina State Univ. Mature, green fruit and fruit turning red were inoculated with conidia. Lesion diameter, percent diseased tissue, and fruit weight were determined daily. The seven cultivars/breeding lines had differing levels of fruit rot resistance and fruit firmness/skin toughness.

094

Strawberry Cultivar Performance and Susceptibility to Tarnished Plant Bug Injury

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Twelve strawberry cultivars established in matted row plots in 1993 were treated with insecticides for tarnished plant bug or left untreated for the 1994, 1995, and 1996 seasons. 'Honeoye', 'Cavendish', and 'Oka' had the highest yields of marketable fruit. 'Jewel', 'Chambly', and 'Kent' had lower, but acceptable, yields. 'Lateglow', 'Blomidon', 'Seneca, NY1424', 'Settler', and 'Governor Simcoe' had lower yields than other varieties. Tarnished plant bug populations were very low during the 1994 and 1996 seasons, and thus feeding pressure may have been too low for any differences in susceptibility between varieties to be expressed. In 1995, when tarnished plant bug feeding pressure was greatest, 'Oka', 'Cavendish', and 'Honeoye' had the lowest injury levels. 'Kent' and 'Lateglow' had the highest levels of injury. Insecticide sprays significantly reduced the percent of injured fruit for most cultivars, but did not significantly increase the weight of marketable fruit harvested. This is due to injury being most prevalent on lower order, and thus smaller, fruit. Cultivars that produced high yields, had low injury levels, and had the least difference between sprayed and unsprayed treatments are most likely to have resistance to tarnished plant bug injury. 'Oka', 'Cavendish', and 'Honeoye' were the most promising cultivars in this regard.

42 POSTER SESSION 1L (Abstr. 095–108) Breeding & Genetics—Genetics/Cell and Tissue Culture

095

In Vitro Shoot Regeneration from Callus Derived from Marubakaido Apple Rootstock under Different Aluminium Concentrations

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The aim of this work was to evaluate the organogenesis of Marubakaido apple rootstock under different aluminium concentrations. The explants were calli derived from apple internodes treated with either 2,4-dichlorophenoxyacetic acid or picloram at 0.5 and 1.0 µM and under five different aluminium concentrations (0, 5, 10, 15, 20 mg/L). These calli were then treated with aluminium at 0, 5, 10, 15, and 20 mg/L. It was observed shoot regeneration only for those calli previously treated with picloram. There were no significant difference among the aluminium concentrations.

096

In Ovule Culture in Peach: Embryo Perforation, Duration of Culture, and Media Effects on Seed Growth and Seedling Survival

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In the breeding of early maturing peach and nectarine cultivars, the use of embryo rescue techniques is invaluable since the embryos of these materials are not mature by the time the fruit is mature. Thus the seed does not germinate under normal stratification/germination procedures. Peach embryos between 3 and 6 mm in length were cultured in ovule on WPM under treatments that varied

in sucrose levels (4% and 6%), the use of vitamins (casein hydrosylate, ascorbic acid, and panthothenic acid) and hormones (BAP and GA₃), and the duration of the treatment (7, 14, 21, and 28 days). A five-seed sample was measured for length, fresh weight, and dry weight before and after treatment. The treated embryos were then cultured in an embryo rescue media (WPM, 3% sucrose) at 5 °C for 45 days in the dark and then brought out to room temperature under lights (12-h day). After 2 to 4 weeks the embryos were rated for germination, size, and root number. Embryo perforation treatment resulted in larger embryos but not in better germination than the smaller unperforated embryos. Among the embryos cultured without perforation, the addition of vitamins and hormones caused the production of plants with more roots and shoots but not necessarily with better survival. Both levels of sucrose worked reasonable well. As the time of in ovule treatment increased, embryo growth and plant survival was enhanced.

097

Shoot Regeneration and Reduction of Contamination of Date Palm (*Phoenix dactylifera* L.)

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This experiment was conducted at the Zaffarania Experimental Station in Baghdad, Iraq. The seeds of date palm cultivars 'Zahdy' and 'Khastawy' were cultured on Murashige and Skoog (MS) medium containing 0.5 mg/L NAA and 2.0 mg/L BA. Seeds were treated with 10, 20, 30, and 40 pulses of excimer laser radiation. The results indicate that these seeds exhibited significantly less contamination than control. The highest percentage germination for both cultivars was obtained with explants treated with 40 pulses excimer laser radiation. Compared to other treatments, the shoot regeneration was greater with seeds from the 'Khastawy' cultivar. Scanning electron microscope showed regeneration occurred about 5 months after.

098

Genetic Modification of 'Royal Gala' Apple by *Agrobacterium*-mediated Transformation and Colchicine-induced Mutation

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As part of a program to develop transgenic *Malus x domestica* Borkh. cv. Royal Gala with improved disease resistance, transgenic diploid and tetraploid plants with cecropin MB39 gene were regenerated. Transgenic diploid plants were obtained from etiolated internodal explants by *Agrobacterium tumefaciens*-mediated transformation using the plasmid binary vector pGV containing a chimeric gene consisting of a secretory sequence from barley- α -amylase joined to a modified cecropin MB39 coding sequence and placed under control of wound-inducible osmotin promoter from tobacco. The integration of the cecropin gene into apple genome was confirmed by Southern blot analysis. The transformation efficiency was 1.5%. Both non- and transgenic tetraploid plants were produced by cocultivating leaf explants from wild type and transgenic diploid shoots with colchicine at 25 mg/L in apple regeneration medium containing 10 μ M TDZ. Twenty-two tetraploid lines were obtained from 90 explants. Flow cytometry was used for ploidy determination. The tetraploid plants were distinguishable from the diploid on morphological as well as cytogenetic grounds. Both the transgenic diploid and tetraploid plants are now being evaluated for resistance to fireblight.

099

Transformation of 'Bosc' Pear (*Pyrus communis* L.) with the *rolC* Gene from *Agrobacterium rhizogenes* and Characterization of Transgenic Plants

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Pear production in the United States relies on a few major cultivars, including 'Bosc'. While there is a need for new cultivars, genetic improvement of the existing major cultivars through genetic transformation could have a major impact on the industry. We have developed a system for regeneration and transformation of pear. While the major objective of the transformation project is to improve resistance to fire blight (*Erwinia amylovora*) in major pear cultivars, tree size control is also one of the objectives in the genetic improvement of pear that may be approached through transformation. Traditionally, manipulation of tree size and vigor in estab-

lished cultivars has been achieved through the use of size-controlling rootstocks. There are no completely satisfactory size-controlling rootstocks for pear. Genetic transformation provides an approach to developing new size-controlling rootstocks and also to directly affect the growth of the transgenic scion cultivar using genes that affect plant growth such as the *rolC* gene isolated from the bacterium *A. rhizogenes*, the causal agent of "hairy root" disease. This gene has been shown to alter growth and development in a number of plant species. To investigate the potential utility of the *rolC* gene in altering the growth of pear trees, 'Bosc' pear was transformed with *A. tumefaciens* EHA101 carrying a pGA482-based plasmid containing the NPTII and GUS genes, and the *rolC* gene under the control of its native promoter. Four clones were isolated that were kanamycin-resistant and GUS-positive. PCR assays and DNA blots indicated the presence of the *rolC* gene in these clones. Each transgenic clone has been multiplied in vitro and planted in the greenhouse where transgene expression and plant growth are being evaluated.

100

Development of an *Agrobacterium*-mediated Transformation System for 'Beurre Bosc' Pear

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An efficient regeneration/transformation system was developed for 'Beurre Bosc' pear. Young leaves were harvested from in vitro shoots proliferated on a medium containing MS basal salts and 5 BAP, 0.5 μ M IBA, and 0.6M3. Shoot regeneration was optimized using a modification of the medium of Chevreau and Leblay (1993). Explants were cultured on shoot induction medium contained 10 μ M TDZ and 1 μ M IBA for 4 weeks in the dark, and then transferred to a similar, but auxinless, regeneration medium until shoots developed, usually after an additional 4 to 8 weeks. Leaf tissues were transformed by co-cultivation for 3 days with *Agrobacterium tumefaciens* EHA101 carrying a pGA482 plasmid containing *NPTII*, *GUS*, and *rolC* genes, followed by cultivation on SIM containing 300 mg/L timentin. Putative transgenic plants were selected on shoot induction medium containing 80mg/L kanamycin, and multiplied on shoot proliferation medium. Four clones were confirmed as transgenic using the GUS histochemical assay and Southern blots for the *NPTII* and *rolC* genes. Plants of each clone have been rooted and successfully transferred to the greenhouse for further analysis of gene expression.

101

In Vitro Propagation of Garlic (*Allium sativum* L.)

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This study was carried out in the Tissue Culture Laboratory and the Experiment Field of the Dept. of Horticulture, Assiut Univ. Two garlic cultivars i.e., El-Balady (local cultivar) and the Chinese were used. Two media, MS and B5, were supplemented with 4%, 8%, 12% and 16% sucrose. The 8% sucrose gave best number of roots, root length and leaf length as compared to the other sucrose concentrations used in this study. Four percent or 16% sucrose gave the lowest values of these characters. The MS gave higher values in most of the studied characters than that of the B5. In another experiment three growth regulators i.e. IBA, BA and GA₃ or used at 0, 5, 10, 20 ppm in two media, MS and B5 supplemented with 3% sucrose. All the studied growth regulators gave higher values than the control in respect of the all studied characters. The IBA was better than BA and GA₃ in root formation, while GA₃ was better than BA and IBA in leaf formation. It is found that 5 ppm of IBA formed the highest number of roots, root length and percentage of root formation. On the other hand, the 20 ppm of GA₃ gave the highest number of leaves and leaf length. The garlic plantlets were successfully acclimatized in the laboratory giving 67.8% survival for the Balady cv. and about 62.6% for Chinese cv. The survival rate of these plantlets were 74.5% for the Balady cv. and 78.5% for the Chinese cv. on transfer to the open-field. No chromosomal aberrations was noticed.

102

Influences of Growth Regulators and Cultivars on Callus and Shoot Production of Alfalfa

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Alfalfa seeds of Cimarron VR, CW1446, CW2440, C94-118, C94-785, and

WL311 were used as explants. BA, zeatin, and TDZ were evaluated on callus initiation, development, and shoot production. Callus initiation and development toward shoot organogenesis were enhanced when BA was added in the culture medium. Calli produced from BA treatments were compact, solid, and dark green. Similar results were obtained when zeatin was added in the culture medium. However, no shoots were produced from such calli. Multiple shoots were produced directly from each individual explant when TDZ was added to culture medium. However, when higher concentration of TDZ was used, number of shoots per explant was decreased, and dwarf shoots were produced. No apparent difference on shoot production was observed among the cultivars tested so far. Data on number of shoots per explant from two of these cultivars need to be statistically analyzed.

103

Use of Microsatellites for the Identification of Potato Somatic Hybrids

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Somatic hybrid plants were obtained through protoplast fusion of monoploid potato. Of three separate fusions, two were interspecific between *Solanum phureja* and *S. chacoense*, whereas one was intraspecific between two *S. phureja* clones. Microsatellites, or SSRs, were employed to distinguish true somatic hybrids from somaclones of unfused protoplasts. Primers flanking eight different SSR loci obtained from GenBank accessions for potato were developed for PCR amplification. Microsatellites consisted of di-, tri-, and tetra-nucleotide repeat units that varied from 4 to 20 repeats per locus. The majority of microsatellites were highly polymorphic between the *S. phureja* and *S. chacoense* clones and the presence of both parental alleles in fusion regenerants indicated their interspecific hybrid nature. One interspecific somatic hybrid could be identified at three of the four examined loci (two tri- and one di-nucleotide repeat loci). The parents were monomorphic at the remaining di-nucleotide repeat, thereby rendering it unsuitable for hybrid identification. A similar result was obtained for another interspecific hybrid, with four of five loci appearing polymorphic between the parents and in the somatic hybrid. Less polymorphism was observed between the parents of an intraspecific *S. phureja* somatic hybrid, with only one locus (a tetra-nucleotide repeat) of five examined showing polymorphism. Results indicate that SSRs are a consistent and reliable means for somatic hybrid identification in potato. In order to reduce the cost and time of maintaining numerous calluses through a lengthy tissue culture regeneration phase, a technique was developed to screen calluses prior to regeneration. Using SSRs and a rapid DNA extraction method, hybrid and nonhybrid calluses could be distinguished rapidly without adversely affecting subsequent regeneration of shoots from the callus.

104

Derivation and Comparison of Androgenic and Gynogenic Monoploid Potato Families

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Monoploid potato ($2n = 1x = 12$) can be derived either paternally through anther/microspore culture or maternally through crossing with a haploid-inducing pollinator. Evidence from other genera suggests that androgenic and gynogenic haploid populations derived from the same parent may differ due to gametic selection and/or epigenetic factors. Our objectives were to derive androgenic and gynogenic monoploid populations from each of two diploid ($2n = 2x = 24$) *Solanum phureja* clones and compare their phenotypic characteristics in a greenhouse study. A haploid-inducing pollinator, *S. phureja* IVP101, was crossed to two selections of *S. phureja* (PP5 and BARD1-3). A total of 185 fruit was obtained from PP5 and 398 from BARD1-3, resulting from 85% and 65% fruit set, respectively. Seed lacking the dominant embryo spot marker carried by IVP101 were selected and germinated in vitro. From 29,300 PP5 x IVP101 seeds, 278 were spotless, resulting in 27 monoploids. Approximately 35 monoploids were obtained from the 99,500 BARD1-3 x IVP101 seeds, of which 500 were spotless. In anther culture, PP5 and BARD1-3 yielded 0.16 and 1.67 embryos per anther, respectively, of which 51% and 44% of the regenerants were monoploid. A total of 32 anther-derived monoploids has been obtained from PP5 and 130 from BARD1-3. Rooted cuttings of 21 androgenic and 21 gynogenic PP5 monoploids were established in a greenhouse in each of three randomized complete blocks. Data were collected on height, vigor, and stem number. Although the gynogenic monoploids appeared slightly more vigorous, there were no significant differences between the androgenic and gynogenic populations for vigor and stem number

($P > 0.05$). Mean height of the gynogenic monoploid population (13 cm) was significantly greater at 4 weeks than the androgenic monoploid population (9 cm); $P < 0.05$.

105

Direct Regeneration of *Pennisetum setaceum* 'Rubrum'

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Pennisetum setaceum 'Rubrum' (Crimson Fountain Grass) is an attractive ornamental grass. It is adaptable to a wide range of soil types and is drought-tolerant. Nodal explants were taken from containerized plants either grown in greenhouse or outside. The explants were surface-sterilized in 95% ethyl alcohol for 10 min followed by 10 min in 10% Clorox bleach and rinsed three times each for 5 min with sterile double-distilled water. The explants were then cultured in glass tubes of 25 x 150-mm filled with half- and full-strength MS medium supplemented with 1 or 3 mg/L BA and 0.5 mg/L NAA. Shoot regeneration occurred within 1 to 2 weeks. The best medium for shoot regeneration was 1/2MS supplemented with 1 mg/L BA plus 0.5 mg/L NAA. Microshoots were transferred into rooting medium consisting of 1/2MS supplemented with 0.25 NAA. Rooting took place within 5 to 6 weeks. Plantlets were then planted in soilless medium, placed under mist for 1 week, and transferred into the greenhouse for further growth.

106

Exogenous Polyamine Application Improves Shoot Elongation In Hazelnut (*Corylus avellana* L.) Micropropagation

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Buds from newly developed shoots obtained from forced outgrowth of mature, unpruned field-grown trees of *Corylus avellana* L. were cultured in vitro on Murashige and Skoog (1962) medium and a Modified Driver and Kuniyuki (1984) medium containing different levels of N-6 Benzyladenine (BA) (1.5, 2.5, or 3.5 mg/L) supplemented with or without a combination of Putrescine (0.2 mM) + Spermidine (0.2 mM) + Spermine (0.05 mM). Shoot elongation varied among genotypes, media and treatment with/or without polyamines. The best shoot elongation occurred on modified DKW medium containing BA plus polyamines.

107

Induction of Callus from Seedling Explants of *Citrus macrophylla* W. Rootstock

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Citrus macrophylla is an important citrus rootstock for Mexican lemon (*Citrus aurantifolia* S.). This study was conducted to select explant type and to optimize cultural requirements for induction callus of *C. macrophylla* in vitro. The explants tested were leaf, epicotyl, cotyledon, and root segments excised under sterile conditions from 4-week-old nucellar seedlings. The various medium comprising either basal of Murashige and Skoog (MS) or Murashige and Tucker (MT) salts supplemented with various concentrations of plant growth regulators, including naphthaleneacetic acid (NAA), 2,4-dichlorophenoxyacetic acid (2,4-D) and 6-furfurylaminopurine (kinetin) were used for the establishment of the explants. All cultured explants initiated callus from the cut ends after 2 weeks, when cultured on a modified MT medium supplemented with 6 mg NAA and 0.2 mg kinetin; cotyledon segments were the best explant for callus induction and development (43 mm²). Root segments were the lowest explants for callus induction.

108

Induction and Culture of Apex of Axillary Shoots of Papaya in Vitro from Mature Field-grown Trees

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The papaya (*Carica papaya* L.) is a tropical fruit tree grown in many coastal region of Colima. The experiments were conducted to optimize cultural requirements for induction and culture of shoot of *C. papaya* cv. Red Lady in vitro. The crown, fruits, and leaves were removed from 1-year-old trees in the field for stimulate growth of lateral shoots with application of 289 μ M gibberellic acid solution along steam surface. Apex (2 x 2 mm) of the shoots induced were established in Drew and Smith (DS) medium containing 1 μ M 6-benzylaminopurine (BAP) and

1 μM naphthaleneacetic acid (NAA). After 90 days of establishment, the explants were transferred to a multiplication medium consisting of DS medium containing different concentrations of BAP and NAA (0:0, 2:0.1, 2:0.5, 2.5:0.5 and 3:0.5 μM , respectively). Individual shoots were excised from the proliferating cultures and subcultured onto fresh medium at 30- to 40-day intervals. The shoot number induced of trees in the field was of 47.5 per plant. After three subculture of shoot the best multiplication factor per subculture (6.9) was when 2 or 2.5 μM of BAP and 0.5 μM of NAA were added to DS medium.

42 POSTER SESSION 1M (Abstr. 109–114) Crop Production—Fruit Cultivar Evaluation

109

Performance of 25 *Carica papaya* Lines in Middle Georgia

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The purpose of this study was to evaluate plant survival, growth, fruiting, and stresses of papaya in middle Georgia and select five to eight superior genotypes for further evaluation and enhancing cold hardiness through biotechnological approaches. Greenhouse-raised seedlings of 25 lines of papaya acquired from National Repository at Hilo, Hawaii, and India, were established in the field during Spring 1995. Replanting of some lines was necessitated by plant losses, extended through Summer 1996 and included some papaya lines from the Univ. of Florida, Homestead. In the initial planting, the plant spacing was 5' x 5' in a RBD with four replications containing four plants of each line. During the winter times, plants were protected by covering the entire area with 6-mil clear polyethylene and providing four electric heaters and six high-speed fans. Observations were made on survival, plant height, fruiting height, fruit data (number, weight, and yield), and tolerance to biotic and abiotic stresses. No female plants of several papaya lines survived. Plant height in May 1997 ranged from 27 to 98 inches, while fruiting heights were 19 to 55 inches. There were 16 fruits per plant with an average weight of 657 g per fruit. Total fruit yield was the highest for FVSU-45 followed by Criolla, and then PI-491601. We did not observe any serious plant stresses other than crown rot and damping-off. Based on above performance, eight lines (HCAR 010, 036, 192, 217, PI-491593, PI-491596, Cariflora, and the FVSU-45) were selected for cold hardiness study in vitro.

110

Performance of Early Ripening Clingstone Peach Selections in South Carolina

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The processing peach industry in South Carolina is largely based on 'Babygold' varieties, which are late-season clingstone peaches. New varieties of high-quality peaches and nectarines with non-melting flesh that ripen earlier would allow more flexibility in seasonal processing schedules and avoid overlap with pome fruits. Twenty-four numbered selections from the Univ. of Arkansas and Rutgers Univ. breeding programs that ripen before 'Babygold 5' were planted in 1995 near Clemson, S.C. Trees were budded on both Lovell and Guardian rootstocks. Bloom dates, fruit maturity dates, fruit yield, weight, soluble solids, firmness, flesh color, and tree growth were taken in 1997. No differences were observed among rootstocks for variety bloom and harvest dates, fruit yields, fruit quality or tree growth. Differences were found among varieties in all traits measured or scored. 'NJC126', 'A378', 'A485', and 'A82-8' ripened the earliest. 'A429', 'A473', and 'A219' ripened the latest, about a week before 'Babygold 5'. 'A378' and 'NJC126' had small fruit (<90 g); whereas 'A473', 'A43-143', 'A9', 'NJC130', and 'NJC142' had large fruit (>170 g). 'A429', 'A473', 'A43-143', and 'NJC142' had the highest yields (31–39 kg/tree). An interaction between variety and rootstock was evident for fruit yield in some scion/rootstock combinations.

111

Evaluation of Industrial Peach Cultivars

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Sixteen industrial peach cultivars from Brazil and 'Flordagold' on 'Nemaguard' rootstock were planted at a 5 x 5-m spacing in 1986. The best cultivars were 'Cap de Bosc', 'Petisco', 'Diamante', and 'Magno', with yields of 32.8, 28.1, 27.6, and 27.2 t/ha, respectively. 'Flordagold' yielded 16.1 t/ha. That maturation period was from 21 June to 19 Aug. The average fruit weight was 80 to 176 g, and soluble solids were 13.1 to 16.1 °Brix. 'Diamante' is the recommended cultivar because of its dual utility (table and industrial). 'Diamante' is characterized by its yellow fruit with stick seed and an average fruit weight of 176 g. It matures in mid-June. One negative characteristic is that the fruit is prone to oxidation, manifesting in a stain. One advantage in growing this cultivar as an industrial product is a reduced need for labor. These results were validated on a 35-ha farm during 1997.

112

Performance of Peach and Nectarine Cultivars in the Gulf Coast Area of Alabama

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There are a limited number of peach and nectarine cultivars available with chilling requirements that perform well in the Gulf Coast area of Alabama. A test planting of 40 peach and 13 nectarine cultivars was established in 1985 at the Gulf Coast Substation at Fairhope, Ala. The plot was prepared and trees grown according to commercial procedures. Blocks of four trees of each cultivar were planted on a 6 x 6-m spacing. Chill hours were calculated each year based on number of hours at or below 7.3 °C starting from and including the first 10 consecutive days a total of 50 h were accumulated to 15 Feb. Data collected included date of full bloom, first harvest date, and total yield. Fruit were measured or rated for skin color, attractiveness, firmness, stone freeness, pubescence, flesh color, dessert quality, shape, weight, percent with split pits, and occurrence of malformed sutures and extended tips. All cultivars were evaluated for 9 years (1987–1995). The peach varieties that performed best in order of harvest date were 'Flordaking', 'Texstar', 'Suzy Q', 'Starlite', 'Sunbrite', 'Junegold', 'Bicentennial', 'Brighton', 'Magnolia', 'Sunland', 'La Feliciana', 'Sam Houston', 'Flavorcrest', 'La Festival', 'La Pecher', 'Idlewild', and 'Rio Grande'. The nectarine varieties that performed best were 'Armking', 'Sunlite', 'Karla Rose', 'Carolina Red', and 'Rose-princess'.

113

Three New Peaches and a Nectarine for the Southeastern United States

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Four new varieties have been released from the USDA-ARS Stone Fruit Breeding program located in central Georgia. All are adapted to the humid Southeastern U.S. climate. 'Rubyprince' is an early yellow-fleshed peach with excellent size, firmness, and color. The slow-softening fruit ripens in early June at Byron, about with 'Dixired', but is slightly lower chilling (about 800 h below 45 °F). 'Blazeprience' is a very firm yellow-fleshed peach with a solid red blush that ripens in late mid-season between 'Harvester' and 'Redglobe'. It is susceptible to bacterial spot disease similar to 'O'Henry'. It requires about 850 chill hours. 'Southern Pearl' is a large white-fleshed, mid-season peach with very good acid flavor and medium firmness. It ripens about with 'Harvester' or 'Redhaven'. Chilling requirement is only about 650 h, similar to 'Springcrest'. 'Juneprincess' nectarine ripens in about the same season as 'Southern Pearl' and produces large, attractive, firm fruit that is less prone to rain cracking than many nectarines. Skin color is bright red, typical of California nectarines, with yellow flesh. Chilling requirement is about 850 h.

114

Cumulative Yield, Tree Growth, and Yield Efficiency of 18 Asian Pear Cultivars

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Eighteen Asian pear cultivars on *Pyrus betulaeifolia* rootstocks were planted in 1990 at Washington State University's Royal Slope Research Unit in central Washington State. Annual trunk diameters have been measured since planting, and annual harvest records have been kept since 1995. The six cultivars with

the largest trees, ranked in decreasing order of trunk cross-sectional area, were 'Daisui Li' (144 cm²), 'Ishiiwase', 'Huhoot Li', 'Shin Li', 'Shinsui', and 'Yoinashi' (123 cm²). The six cultivars with the smallest trees were 'Twentieth Century' (91 cm²), 'Chojuro', 'Shinseiki', 'Shinko', 'Yakumo', and 'Tarusa Crimson' (38 cm²). 'Tarusa Crimson' was significantly smaller than all other cultivars. The six highest-yielding cultivars, ranked in decreasing order of cumulative yield, were 'Daisui Li' (183 kg/tree), 'Shinseiki', 'Shin Li', 'Shinko', 'Chojuro', and 'Olympic' (107 kg/tree). 'Daisui Li' had significantly higher cumulative yield than all other cultivars. The six lowest-yielding cultivars were 'Yoinashi' (71 kg/tree), 'Huhoot Li', 'Tarusa Crimson', 'Yakumo', 'Shinsui', and 'Nangon Li' (19 kg/tree). The six highest-ranking cultivars for cumulative yield efficiency were 'Shinseiki' (1.6 kg·cm⁻²), 'Shinko', 'Chojuro', 'Daisui Li', 'Tarusa Crimson', and 'Olympic' (1.2 kg·cm⁻²). The six least-efficient cultivars were 'Ishiiwase' (0.7 kg·cm⁻²), 'Yakumo', 'Yoinashi', 'Huhoot Li', 'Shinsui', and 'Nangon Li' (0.2 kg·cm⁻²). 'Daisui Li' and 'Tarusa Crimson' had similar, relatively high, cumulative yield efficiencies, but for different reasons. 'Daisui Li' produced high yields on large trees while 'Tarusa Crimson' produced low yields on small trees. In contrast, the relatively high efficiencies of 'Shinseiki', 'Shinko' and 'Chojuro' resulted from high yields produced on small trees.

83 POSTER SESSION 2A (Abstr. 115–118) Floral/Seed/Crop Physiology — Fruits/Nuts

115

Wax Morphology and Gas Exchange of Peach and Apple Leaves as Influenced by Soybean Oil Emulsions and Rain

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A study was conducted to investigate the influence of rain on retention of soybean oil emulsions and their influence on wax morphology and gas exchange of apple and peach leaves. Peach and apple trees were grown in 19-liter pots in a greenhouse (25 °C). Two different soybean oil emulsions were sprayed on trees in a randomized block design with five replications. Twenty-four hours after the oil sprays, the trees were subjected to three rainfall regimes, 0.25, 1.25, and 2.54 cm. The surface wax and the oil residue on leaves were determined gravimetrically after chloroform extraction. A negative relationship existed between rainfall and oil retention. Peach leaves receiving 0.25, 1.25, and 2.54 cm rainfall lost 19%, 62%, and 82% of the applied oil, respectively. There were no differences in oil retention between top, middle, and bottom layers of the canopy, indicating that leaf age did not influence oil retention. Oil residue loss from apple leaves was similar to that from peach. Scanning electron microscopy revealed that the leaf wax morphology was not affected by the soybean oil emulsions and occurred as striations on both leaf surfaces. However, one of the emulsions partially washed off the waxes from apple leaf surfaces whereas the other emulsion did not exhibit this phenomenon. Furthermore, both of the soybean oil emulsions induced partial or full stomatal closure, which influenced stomatal conductance and transpiration.

116

Influence of Stratification and Seed Age on Germination of *Penstemon* Seeds

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Seeds of eight *Penstemon* selections, stratified for 10, 8, 6, 4, 2, or 0 weeks in 1989 and 1990, displayed significant germination differences between species, between weeks of stratification, and between years. Germination varied from zero with *P. digitalis* in both 1989 and 1990 with no stratification, to 68.0% and 72.8% with *P. angustifolius* in 1989 and 1990, respectively, for 10 weeks of stratification. In 1991 through 1997, seeds of four of the selections were stratified for 0 or 8 weeks. Seeds that were 3 to 4 years old germinated as well as or better than seeds 1 to 2 years old. All seeds that were 9 years old had no germination, except for *Penstemon* 'Prairie Splendor', which averaged 7% germination with no stratification. Stratification significantly increased germination of seeds up to 4 years old. Germination of *Penstemon* seed varied with stratification, seed age, and species/line.

117

Morphological, Anatomical, and Chemical Characterization of Guanabana Seeds, *Annona muricata* L.

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This study was carried out to determine the physiological factors affecting seed germination of a tropical fruit guanabana, *Annona muricata* L. The ontogeny of the seed was studied looking for the identification and determination of the seed coat, ruminated endosperm, and endosperm tissues. Four development stages of the seed were considered: very tender, tender, juvenile, and mature. Cross, longitudinal, longitudinal-medium, cross-basal, and longitudinal-basal sections were done using the cryostat microtome. Portions were done of about 5 µm thick. Portions of cross-sections of the seed coat showed the transversal and oblique fibers of this tissue, which constitutes an impermeable layer in the seed. Medium-longitudinal-sections showed the distribution of the ruminated tissue and it was observed the micropylar stopper and the hilum cavity rounded by the collarete. This cavity is the only structure that permits the water diffusion through the seed. It was found that the hilum cavity is communicated to the endosperm through little crevices that are formed by the non-vascular ruminated tissue. The miniature embryo, which is embedded by the endosperm, is surrounded by the ruminated tissue. The qualitative chemical composition of the mature endosperm showed the distribution of proteins, starch, lipids, and sugar content. A high content of lipids was detected in these seeds (33%) using the soxhlet extraction method.

118

Main Physiological Factors Affecting the Germination of *Annona muricata* L. Seeds

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Dormancy and latency factors such as moisture content, temperature, growth regulators, and seed-coat affecting germination of the *Annona muricata* L., a tropical fruit, were studied. Three types of fruits were used with presence of styler residues (medium and big size) and absent of styler residues. The fruits were taken from 4-year-old trees, which were naturally pollinated. A complete randomized design was used for the study, with 50 seeds per experimental unit and four replications per treatment. The variables measured were days and percent of germination, and average germination velocity. The seed germination was affected by the moisture and oxygen content, because the structure of the seed and their high content of the lipid in there. The length of the germination period was determined by the concentration of the exogen hormones applied, the temperature range, the kind of scarification used, the substrate utilized and the moisture content present during the assays. Highly significant differences were found among treatments. The optimal conditions for germination (97.5%) were: 30 °C of temperature, no scarification, sand as substrate, and 750 ppm of gibberellic acid. The average of days to germination was 24.5 days. No significant differences were found for the different kind of fruits used in this assay. The results showed that this species presented characteristics of recalcitrant seeds.

83 POSTER SESSION 2B (Abstr. 119–133) Root Zone: Irrigation & Nutrition — Floriculture/Foliage/Greenhouse Crops

119

Use of De-inked Paper Sludge in Potting Mixes for Geranium and Zinnia Production

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De-inked paper sludge from newsprint recycling was evaluated as an alternative amendment in bedding plant production. 'Sweet Dreams' geranium (*Pelargonium x hortorum*) and 'Crystal White' zinnia (*Zinnia angustifolia*) were grown in square 10-cm pots in one of five media. Media contained 0%, 20%, 40%, 60%, or 80% de-inked paper sludge by volume. All mixes contained 10% perlite, and peatmoss was used to bring the volume to 100%. Initial chemical and physical

characteristics of the media were determined. Plants were grown in a greenhouse for 8 weeks, and then plant height, shoot dry weight, and average plant width were determined. Media containing 20% or less paper sludge had an average pH of 4.4, whereas those containing more sludge had an average pH of 7.0. Cation exchange capacity of the media decreased significantly as the volume of sludge increased. Media containing 60% or more paper sludge were better aerated, but held less water than those made with 40% or less de-inked sludge. Geraniums grown in 20% or less paper sludge were at least 18% taller than those grown in medium containing 40% or more de-inked sludge, but average dry weights and plant widths of these plants were unaffected by the media. Zinnia plants grown in 20% or less paper sludge produced four times more shoot dry weight and were at least 34% taller and 20% wider than those grown in 40% or more sludge. Overall, zinnias grown in 40% or more sludge were unacceptable for commercial sale. A volume of 20% de-inked paper sludge could safely be included in potting media used for production of 'Sweet Dreams' geranium and 'Crystal White' zinnia.

120

Co-blended Composts for Production of Potted Chrysanthemum

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Blending polymer dewatered biosolids (PDB), poultry litter (PL), and yard wastes (YW) composts improved the usefulness of these composts as potting substrate. This study was to evaluate the optimum blending ratio of these three composts for potted chrysanthemum production. 'Boaldi', 'Yellow Boaldi', and 'Red Akron' were planted in six compost blends at compost levels of 75% and 100% and two commercial substrates. The PDB, PL, and YW composts were blended on a 2:1, 1:1, and 1:2 ratios (v/v); Sunshine mix 1 and Pro Gro 300S were the control. All treatments were replicated five times. Plants were fertilized with 150 or 300 mg·L⁻¹ N from 21N-2.2P-16.6K once weekly. Plants grown in blends at the 75% compost level and 300 mg·L⁻¹ N treatment produced greater number of branches, flower buds, plant height, plant width, and plant grade than those at 100% compost level and 150 mg·L⁻¹ N treatment. The PDB + YW blends at the 75% compost level and high-fertility treatment produced premium-quality plants that were better than any of the control plants.

121

Producing Blue and Pink Flowers on Hydrangea Using Coal Bottom Ash as a Media Component

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Rooted terminal tip cuttings of hydrangea (*Hydrangea macrophylla* Thunb. 'Blauweise Lace Cap') were transplanted into 10-cm azalea pots containing 1 peat : 1 vermiculite (by volume) into which CBA (sieved through 6-mm screen) had been mixed at 0%, 25%, or 50% on 18 Aug. 1996. They were then grown until bud maturation on 21 Nov., precooled, and brought into the greenhouse for forcing on 9 Jan. 1997. The substrate pH levels were adjusted to 6.0–6.5 for pink flowers with dolomitic lime and with Al₂(SO₄)₃ to a pH range of 5.0–5.5. Measurements were performed at anthesis on 19 Apr. There were no significant differences in fresh and dry weight and root quality index from 0% through 75% CBA media, but these parameters were reduced in 100% CBA for both blue- and pink-flowered plants. Plant heights and diameters were equal in 0% through 75% CBA and ranged from 16.33 to 17.56 cm and 17.33 to 18.06 cm, respectively, but were significantly reduced in 100% CBA for blue-flowered plants. Plant heights and diameters were equal in 0% through 100% CBA for pink-flowered plants and ranged from 21.0 to 24.0 and 19.3 to 23.5 cm, respectively. Diameters of blue inflorescences ranged from 95.9 to 104.9 cm, and these were equal on plants in 0% through 100% CBA. However, diameters of pink inflorescences ranged from 114.2–155.6 cm and were significantly reduced on plants in 25%, 50%, and 100% CBA.

122

New Guinea Impatiens Flower Life and Growth Response to Coal Bottom Ash Level in the Root Substrate

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On 26 Mar. 1997, New Guinea impatiens (*Impatiens* x New Guinea) cultivars 'Aglia', 'Anaea', 'Bora-bora', and 'Dark Delias', were planted in 1 peat : 1 vermiculite

(v/v) rooting media containing 0%, 25%, or 50% by volume of coal bottom ash (CBA) that had been sieved through 6-mm mesh. Individual flower longevity was recorded from the first day of flower opening until senescence. There was no significant effect among levels of CBA on flower longevity. However, flower life varied significantly among cultivars from 9.5–9.9 days in 'Aglia' to 15.1–15.8 days in 'Dark Delias'. Per-plant bloom numbers increased linearly with increase in percent CBA for all cultivars. Plant diameters were reduced by CBA in 'Aglia', but not affected by CBA in the other three cultivars. Plant heights of 'Dark Delias' were increased at 50% CBA over that of plants in 0% CBA. Visual quality indices were significantly greater for plants in CBA media compared to that for plants in 0% CBA. Top fresh and dry weights within each cultivar were equal among CBA levels. Within cultivars, there were no significant differences among plants at different CBA levels in plant transpiration rate, stomatal conductance, and net photosynthesis when measured with an LCA3 Leaf Chamber Analyser. However, there were significant differences in these processes among cultivars.

123

Dry Weight Partitioning among Roots, Shoot Bottoms and Tops, and Leaves of *Hydrangea macrophylla* Cuttings Rooted in Coal Bottom Ash or Peat : Perlite Media Containing Four Levels of Dolomitic Limestone

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Terminal tip cuttings of hydrangea (*Hydrangea macrophylla* Thunb. 'Blauweise Lace Cap') were rooted in 100% coal bottom ash (CBA) sieved through 2-mm mesh or 1 peat : 1 perlite (v/v) containing 0, 3, 6, or 18 g·L⁻¹ of dolomitic lime on 13 July 1997. Rooting performance of the terminal cuttings was monitored weekly for 5 weeks. The pH values were 7.0–7.8 (100% CBA media), 6.3–6.9 (peat:perlite, 18 g·L⁻¹ lime), 6.0–6.5 (peat:perlite, 6 g·L⁻¹ lime), 4.2–5.2 (peat:perlite, 3 g·L⁻¹ lime), and 3.6–5.2 (peat:perlite, 0 g·L⁻¹ lime). Leaf tissue Ca was higher in 100% CBA than that in peat:perlite media after the 2nd week, implying that uptake from the media may have occurred. Total fresh weight of the rooted cuttings increased significantly over 5 weeks and, at week 5, the highest cutting fresh weights were in peat:perlite media with 3, 6, or 18 g·L⁻¹ of lime. No significant differences in shoot tip fresh and dry weights were observed among peat:perlite media, but these were reduced in 100% CBA. Root dry weight and root quality indices were greater in peat:perlite media with 3, 6, and 18 g·L⁻¹. The poorer rooting of hydrangea cuttings in CBA was attributed to the supraoptimal pH range and the substantially lower air capacity (5.25% by volume) compared to that of peat:perlite (15.1%). The superior rooting in peat:perlite media with lime may have been due to the favorable pH range.

124

Evaluation of Zeolite-based Soilless Root Media for Potted Chrysanthemum Production

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Chrysanthemum growth and nutrient leaching of three clinoptilolite-based root media, which were formulated and provided by Boulder Innovative Technologies, Inc. and ZeoponiX, Inc., were compared to the performance of control plants grown in Sunshine Mix #2 (3 peat : 1 perlite, v/v). The control received 210 mg·L⁻¹ N from an 18N-4P-15K soluble fertilizer at each irrigation. The experimental zeolite-based medium NZ, which contained untreated zeolite and received the same soluble fertilizer as the control, leached lower concentrations of NH₄-N, K, and PO₄-P for most of the production cycle compared to the control. Medium EZ1 was formulated to provide N, P, and K as fertilizer nutrients and produced plants similar to the control based on ratings, height, width, and dry mass, but not fresh mass, at harvest when the fertilizer rate was half of that applied to the control, 105 mg·L⁻¹ N. Medium EZ2, which did not receive P or K from soluble fertilizer, produced plants similar to the control based on rating, height, and dry mass, but not width or fresh mass, with soluble fertilizer input reduced to only N. Tissue N, P, and K concentrations of plants grown in media EZ1 and EZ2 were lower than those of control plants. With further refinements, these zeolite-based products show promise for decreasing nutrient leaching during crop production and allowing for application of lower rates of soluble fertilizers.

125

Growth and Nutrient Response of Petunia and Marigold in Tire-containing Media

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This study was conducted to determine the feasibility of using rock phosphate and acid pretreatment to reduce Zn availability in root media containing waste tire material for petunia and marigold production. *Petunia x hybrida* 'Ultra Crimson Star' and *Tagetes patula* 'Orange Boy' were grown in the greenhouse in media consisting of 4 perlite : 6 peat (v/v), 4 tire : 6 peat (v/v), or 4 tire (acid washed with 0.5 N HNO₃) : 6 peat (v/v); and containing various amounts of finely crushed rock phosphate ranging from 0 to 40 g. Bulk density was higher, while container capacity was lower in tire-containing media; air-filled porosity was comparable in both tire- and perlite-containing mixes. Total plant dry weight was highest in both crops grown in 4 perlite : 6 peat. Tissue concentrations of Zn were 2- to 3-fold higher in plants grown in media containing tire material. Tissue P was lower in petunia grown in tire media, but not in marigold. Compared to untreated tires, acid washing of tire components reduced tissue Zn levels in both crops, but had little effect on growth response. Visual analysis indicated that crop quality in tire media was unsatisfactory for petunia, but acceptable in marigold. Rock phosphate reduced leachate Zn levels in marigold, but not in petunia, and had no significant effect on growth and nutrition response in either crop. The data suggest that in addition to Zn, some other factor(s) may have limited growth of both species in tire-containing media.

126

Enhanced Growth of Amaryllis (*Hippeastrum hybridum*) Seedlings in Horse Manure Medium

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An experiment was conducted to compare the growth of amaryllis seedlings in the following media: pure horse manure, 1:1 garden soil–horse manure (v/v), and 1:1 garden soil–wood shavings (v/v). Final values for fresh weight increment, dry weight, leaf area, leaf area index, leaf length increment, bulb width increment, leaf area ratio, and crop growth rate were significantly highest and lowest in horse manure and 1:1 garden soil–wood shavings, respectively. Net assimilation rate, relative growth rate, and moisture content were similar for all treatments.

127

The Response of Marigold (*Tagetes patula*) Roots in Copper-treated Plug Containers

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A study was conducted with marigold 'Little Devil Flame' to evaluate the effects of copper-treated containers on root system development in marigold (*Tagetes patula*). The internal walls of plugs were painted or without SpinOut (Griffen Corp., Valdosta, Ga.), a form of cupric hydroxide in latex paint. Two marigold seeds were sown directly into the plugs filled with MetroMix 360 (Scott's) and thinned after 5 days. Plants were grown under standard greenhouse conditions. After 14 days, half of the plants were transplanted into 6-packs and in the other half medium was washed from and the root system were digitally analyzed using MacRhizo (Regent, Inc.). Shoot and root dry weight also were collected. Five days later, the same data were collected from the transplanted plants. Copper hydroxide reduced root and shoot growth prior to transplanting. Average root length of untreated plants was 41% larger than copper treated plants before transplanting and 25% larger after transplanting. There were no carryover effects of the copper on subsequent root growth. Copper-treated plants grew an average of 59.3 mm, while untreated plants grew 53.1 mm after transplanting. Root tips were killed when they contacted the copper-treated container surface. These roots had shorter internal and external link lengths and a greater average root diameter. It appears that the initial effect of copper on marigold roots system is to kill the root tip and inhibit further elongation. Overall branching pattern in the root system was not altered until after transplanting.

128

Effect of Fertilizer Concentration on Growth of Variegated and Non-variegated Double Impatiens

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Double impatiens (*Impatiens wallerana*) 'Blackberry Ice' (variegated-leaf type) and 'Purple Magic' were grown on flood benches and irrigated with 50, 100, 200, or 300 mg·L⁻¹ N to study the effect of fertility on growth and development. Leaf, stem, bud, and total shoot dry mass exhibited a quadratic concentration effect with maximum growth for both cultivars occurring at 100 mg·L⁻¹ N. Tissue concentrations of N, P, and K exhibited a quadratic concentration effect and increased with fertilization concentration, however, levels were higher for 'Blackberry Ice' than 'Purple Magic' over all fertilization concentrations. Tissue Mg levels also increased with fertilization concentration, but levels were higher for 'Purple Magic'. Tissue Ca concentrations were similar for both cultivars and levels decreased as the fertilizer concentration increased. For maximum shoot growth and flower bud production, growers should apply 100 mg·L⁻¹ N when growing double impatiens on flood benches.

129

Effect of Slow-release Fertilizer Concentration and Placement on Petunia Growth in Two Irrigation Systems

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Our objective was to compare growth and flowering of petunia 'Ultra Red' in top-watered and subirrigation systems at four slow-release fertilizer concentrations and at four different fertilizer placements in the pot. Petunia plugs were transplanted into 400-ml pots filled with 60% peat: 25% vermiculite: 15% perlite (by volume). Prior to planting, Osmocote 14N–6.2P–11.6K was either top-dressed (TD), placed in the middle of the pot (M), placed at the bottom of the pot (B), or incorporated into the medium at rates of 0.5, 1.0, 2.0, or 3.0 g/pot. Petunia shoot dry mass linearly increased as fertilizer concentration increased. Top-watered petunias had significantly greater shoot dry mass than subirrigated petunias. Best petunia growth in both irrigation systems was in media with fertilizer at I, TD, or M compared to growth in media with fertilizer at B. Leachate soluble salt concentrations from top-watered benches were consistently 2x greater than concentrations from subirrigated benches. However, leachate NO₃-N concentrations were not different throughout the experiment for subirrigated benches but decreased over time for top-watered benches. Midpoint and final media soluble salt and NO₃-N concentrations were not different between the two irrigation systems. As fertilizer concentration increased, midpoint and final media soluble salt and NO₃-N concentrations linearly increased.

130

Interaction Between Powdery Mildew and N and K Fertility in Begonia

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Nine fertility treatments, consisting of a 3 x 3 factorial arrangement of three N rates (30, 120, 240 µg·ml⁻¹) and three K rates (30, 120, 240 µg·ml⁻¹), were applied by constant liquid feed to cuttings of *Hemalis begonia* 'Hilda' grown in 15-cm plastic pots containing 7.5 peat : 2.5 perlite medium. Prior to transplanting, one-half of the plants were naturally inoculated with *Erysiphe cichoracearum* to induce powdery mildew infection; while the remaining plants received weekly application of Bayleton (Triadimefon). Shoot growth in fungicide-treated plants increased with increasing rates of both N and K, with highest dry matter production (≈8.0 g/plant) with either 120N–240K or 240N–120K. Disease development in plants treated with fungicide was slight, averaging < 7% of the total leaf surface area infected with mildew, irrespective of N and K rates. Shoot dry weights in inoculated plants were markedly repressed, averaging 3.1 g/plant, as disease occurrence was extensive in all treatments. Significant interactions between N and K fertility affected mildew development in inoculated plants. At the high rate of N, K nutrition had little effect on mildew rating, whereas at 30N and 120N, mildew counts decreased with increasing K rate up to 120 K.

131

The Effect of Field Irrigation Practices on Disease Suppression in *Zinnia elegans*

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The objective of this study was to determine if field irrigation practices affect

the development and suppression of three diseases, alternaria blight (*Alternaria zinniae*), powdery mildew (*Erysiphe cichoracearum*) and bacterial leaf and flower spot (*Xanthomonas campestris* pv. *zinniae*), on *Zinnia elegans*. Many commercial growers will no longer produce this popular bedding plant and cut flower crop due to high incidence of these three diseases. Plants of 17 different varieties of *Z. elegans* were started from seed and transplanted into cell-packs to be grown on as bedding plants. They were later transplanted into the field and subjected to one of three watering regimes: natural rainfall plus overhead irrigation, natural rainfall plus sub-irrigation, and natural rainfall only. Weekly evaluations were performed to rate each variety on its susceptibility to disease based upon severity of infection as well as portion of plant affected. Results will be presented on irrigation method and its influence on disease susceptibility and resistance on the 17 varieties evaluated.

132

Evaluation of Disease Resistance among 57 Varieties of *Zinnia elegans*

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Fifty-seven of the most widely grown, commercially popular varieties of *Zinnia elegans* were evaluated for disease susceptibility under uniform field conditions. Plants were started from seed and transplanted into cell-packs to be grown on as bedding plants. They were later transplanted into the field and observed for development and progression of the diseases alternaria blight (*Alternaria zinniae*), powdery mildew (*Erysiphe cichoracearum*), and bacterial leaf and flower spot (*Xanthomonas campestris* pv. *zinniae*). Evaluations were performed throughout the growing season in order to rate each variety on its susceptibility to disease based upon severity of infection as well as portion of plant affected. Results will be presented on disease susceptibility and resistance of the 57 varieties evaluated.

133

Use of Digital Analysis of Radicle Extension of Marigold Seedlings as an Early Indicator of Seed Vigor

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Several seed vigor tests were conducted on Marigold 'Little Devil Flame' and correlated with digital analysis of radicle extension. Seed from a single lot was deteriorated by the accelerated aging (AA) method at 41 °C for 24 and 72 h. Seed moisture content of unaged seed was 15.23%, mildly aged seed (24-h AA) was 40.77%, and moderately aged seed (72-h AA) was 52.85%. After AA treatment, all seeds were dried to near 15% moisture. Vigor level was assessed 7 days after AA treatment by standard germination and soilless-mix plug emergence tests according to the Association of Official Seed Analysts Rules for Testing Seed. The standard germination test revealed an 84.5% germination for unaged seed, 49.5% germination for mildly aged seed, and 28.5% germination for moderately aged seed. The plug emergence test showed an 88.9% normal emergence for unaged seed, 65.28% germination for mildly aged seed, and 9.72% germination for moderately aged seed. Additionally, the radicle of seedlings established under standard germination conditions was digitally analyzed after 4 days. According to digital analysis, average radicle length for unaged seed was 2.10 cm, 1.91 cm, for mildly aged seed, and 1.27 cm for moderately aged seed. Radicle length after 4 days showed an R^2 of 0.81 when regressed against standard germination and an R^2 of 0.99 with seedling emergence tests. These results suggest that digital analysis of radicle extension could provide a sensitive, reproducible test for seed vigor.

83 POSTER SESSION 2C (Abstr. 134–141) Crop Production—Small Fruits & Viticulture

134

Viticultural Performance of Thirteen Rootstocks Grafted to 'Chardonnay' in the Russian River Valley, Sonoma County, California

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Thirteen grapevine rootstocks grafted to *Vitis vinifera* L. 'Chardonnay' clone 4 were compared over 5 years of fruiting in a replicated trial. The scion and all rootstocks were certified as virus tested and true-to-type. Green-growing bench grafted vines were planted in 1989 and vine growth and yield component data collected in 1993–1997. Planting density was 2.44 x 3.66 m vine by row (1122 vines/ha). All vines were harvested on one date each year. Analyses conducted on the 5-year averages of most parameters indicated the year by treatment (rootstock) interaction was significant ($P < 0.05$). Within years, rootstock response was significantly different for most parameters. In the last 3 years (1995 to 1997), AXR#1 and 5C were among the highest-yielding stocks, ranging from 15.2 to 26.8 kg/vine and 13.8 to 26.1 kg/vine, respectively. Among the lower-yielding stocks during the same period was 101-14, which ranged from 11.6 to 22.9 kg/vine. Other low-yielding rootstocks included 110R and 779P. Vine yield was not highly correlated with either cluster number or cluster weight in any year; however, AXR#1 consistently produced among the highest number of clusters per vine. 5C had the greatest pruning weights in 1994 and 1995 (3.2 and 3.1 kg/vine, respectively) and 1045P had the highest in 1996 (2.4 kg/vine). 1045P also had the greatest shoot weights in each of the last 3 years for which pruning weights are available (1994–96). In 1994 and 1995, 101-14 had among the lowest shoot weights and shoot numbers per vine.

135

Selection of Cold-hardy Rootstocks

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Cold-hardy candidates from the Univ. of Minnesota *Vitis* collection were evaluated for potential use as commercial rootstocks for the production of cold-tender grapes in conditions typical of the eastern and midwestern United States. The 53 genotypes studied were selected from the collection based on past field performance and cold-hardy parentage. These were compared with standard commercial rootstocks for these regions—C3309 and SO4—for characteristics typically evaluated in rootstock production: rooting ability, vigor, phylloxera resistance, disease resistance, first season root development, suitability of rootstock wood, ease of grafting and callusing, and growth of scion bud. In addition, indications of onset of dormancy were monitored to identify those genotypes with potential to influence scion dormancy regime for the purpose of increasing scion cold-hardiness.

136

Assessing Organic Nitrogen Acquisition of Ericoid Mycorrhizae in Highbush Blueberry (*Vaccinium corymbosum* L.) Plants by Using an ¹⁵N Tracer

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The ability of mycorrhizalighbush blueberry plants to acquire soil organic nitrogen under different organic amendment regimes was investigated in a field experiment by using an ¹⁵N tracer. Plants inoculated with an ericoid mycorrhizal isolate from the genus *Oidiodendron* had lower leaf ¹⁵N enrichment than uninoculated plants, indicating mycorrhizal (M) plants absorbed more unlabeled soil nitrogen than nonmycorrhizal (NM) plants. The unlabeled nitrogen was presumably from soil organic N sources which might be less available to NM plants. M plants produced more plant dry weight and larger canopy volume, presumably as a result of improved N acquisition ability. In the study, the effect of pre-plant organic amendments on the growth ofighbush blueberry plants was clearly demonstrated. The forest litter amendment produced higher dry mass than either the rotted sawdust amendment or no amendment. The rotted sawdust amendment produced the smallest plants. These results suggested that organic amendments with different C:N ratios might have affected soil N availability by affecting the N mineralization process. The implication of these findings in the production ofighbush blueberry in mineral soils will be discussed.

137

Nitrogen Acquisition Efficiency of Ericoid Mycorrhizae in Highbush Blueberry (*Vaccinium corymbosum* L.) Plants

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In laboratory and growth room experiments, protease activity among a diverse group of ericoid mycorrhizal fungi (isolated from two native and two commercial blueberry sites) was screened via a sensitive fluorescent assay and the efficiencies of mycorrhizal symbionts to use organic (a protein) and inorganic N were determined. There were differences in extracellular protease activity among mycorrhizal isolates within the same genera. Two isolates from a native blueberry site showed the highest extracellular protease activity. Plants inoculated with these two isolates produced more dry weight as compared to the control or plants inoculated with other isolates with lower protease activity when protein was used as the sole nitrogen source. These results suggested that some of the mycorrhizal isolates from native blueberry sites might be more efficient in acquiring soil organic N than those isolated from commercial blueberry sites. This possibility was further examined by using ^{15}N and the results from ^{15}N labeling will be discussed. Our study indicated that it was possible to isolate and identify ericoid mycorrhizal fungal strains which might be useful to increase the host's ability to utilize soil organic N sources.

138

Spot Treatment of Granular Hexazinone in Wild Blueberries

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Preemergence application rates of hexazinone have been reduced because of the concerns of it leaching into the groundwater. Spot treatments of a 10% granular formulation of hexazinone, Pronone MG, would allow for selective post-emergence control of weeds not controlled by the reduced preemergence rate. For each weed species, St. Johnswort, bunchberry, bracken fern, dogbane, and witchgrass/fall panicum, 10, 1-m² plots were established and treated with either 0, 1 or 2 hg/ha a.i. Pronone. Treatment dates were: 27 June 1996 for St. Johnswort, bunchberry, and bracken fern and 12 July 1996 for dogbane and witch grass/fall panicum. Cover was evaluated on 25 July and 17 Sept. 96. Weed and blueberry cover were assessed on 25 June 1997. Dogbane and bracken fern were initially controlled the first year with the 2 kg/ha rate of Pronone being most effective. In the year after treatment, the dogbane at both rates and the bracken fern treated with the low rate recovered. St. Johnswort, witchgrass/fall panicum, and bunchberry was not significantly reduced by the postemergence treatment of Pronone. Heavy rainfall after treatment dates, including more than 3 inches of rainfall on 13 July 1996, may have influenced the hexazinone movement and reduced its effectiveness. The uncertainty of the timing and amount of precipitation make the success of this method doubtful.

139

Impact of an Open Trellis on Canopy Growth, Light Interception, Yield, and Leaf Physiology of Red Raspberry (*Rubus idaeus*)

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After promising results were obtained with an open-style split trellis (two top wires) in its initial year, two new trials were established in 1997 in northwest (Lynden) and southwest (Woodland) Washington. For the split trellis, actual yields were 33% (machine-picked 1/2 season) and 17% (hand-picked) greater, respectively, for the two locations compared to the conventional trellis (one top wire). In Woodland, canes from the split trellis had 33% more berries, 55% more laterals, 69% more leaves, and 25% greater leaf area compared with the conventional trellis. Greatest enhancement of these components was in the upper third of the canopy. Laterals were also shorter in this area of the split canopy, but there was no difference in average total length of lateral/cane between trellis types. Total dry weight/cane was 22% greater in the split trellis, but component partitioning/cane was consistent between the two systems with fruit + laterals (43%) having the greatest above-ground biomass, followed by the stem (30% to 33%) and the leaves (21% to 22%). Measurement of canopy width, circumference, and light interception showed that the split-trellis canopy filled in more quickly, and was larger from preanthesis through postharvest. Light interception near the top of the split canopy was 30% greater 1 month before harvest with 98% interception near the top and middle of that canopy. There was no difference between the trellis types in leaf CO₂ assimilation, spectra, or fluorescence through the fruiting season, or in total nitrogen of postharvest primocane leaves.

140

Toxicity of Minor and Micronutrients in Cranberry

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Cranberry showed significant yield response to applied fertilizer. Some growers apply large quantities of some minor and micronutrients in an effort to increase yields. Tissue levels for nutrient sufficiency and excess have been determined in cranberry, but toxicity levels have not been determined. We exposed rooted cuttings of 'Stevens' cranberry (*Vaccinium macrocarpon* Ait.) to high concentrations of individual nutrients in solution culture and then aeroponics. Shoot boron concentration rose rapidly, but not root concentration. At 300 ppm boron, leaf necrosis appeared and dry weight accumulation slowed. Copper and zinc accumulated in roots, but not in tops and thus will be difficult to diagnose. Shoot growth slowed with elevated root copper. Sulfur accumulated quickly in shoots and reduced growth when it exceeded 0.65%. These tissue levels are far higher than historical results from grower samples.

141

Horticultural Perspective: History of White Pine Blister Rust

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White pine blister rust, *Cronartium ribicola* J. C. Fischer, requires a pine (*Pinus* L.) and a *Ribes* L. as obligate alternate hosts. The center of diversity for this rust is east of the Ural Mountains, where the organism evolved with *P. cembra* L. and *R. nigrum* var. *sibericum* L. over several million years. Susceptible *Pinus strobus* L. from North America was imported into England in 1710 and was transplanted throughout eastern Europe. In 1865, rust was first reported on these introduced pines in Eastonia. In the late 1800s, the white pine nursery industry continued to develop in Europe, but was declining in the United States. American foresters began importing white pines from Europe. Rust was found on cultivated currants in New York in 1906 and U.S. inspectors began examining for the disease. In 1910, infected white pines were imported from France into Vancouver, British Columbia; in 1911, infected pines were found in New Hampshire, Vermont, Massachusetts, Connecticut, Pennsylvania, Indiana, Ohio, Ontario, and Quebec. Additional rust-infected imported pines were found in nurseries in Wisconsin in 1913, and Minnesota in 1914. Rust spread to native pines in New York by 1915 and to Idaho by 1927. A summary of the blister rust control program, the recent spread of the disease, and the present state regulations will be presented.

83 POSTER SESSION 2D (Abstr. 142–149)

Postharvest Physiology—Temperate Fruit Crops

142

A Contrast in Ethylene Production and Respiration between Melting- and Nonmelting-flesh Peaches

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A connection between ethylene production and the melting trait in peaches has been reported by other authors. In our study, we refute the notion that ethylene production levels in nonmelting-flesh (NMF) peach (*Prunus persica* L.) fruit are normally lower than those in melting-flesh (MF) fruit. While in fact during ripening NMF fruit ('Oro A' and FL 86-28C) reached lower firmness levels than MF (FL 90-20 and 'TropicBeauty') fruit did, NMF fruit produced consistently higher levels of ethylene than MF counterparts. In both MF and NMF genotypes, fruit from later harvests were in a more advanced phase of their ethylene production and respiratory drift than those from earlier harvests. Fruit size did not necessarily influence levels of respiration or ethylene production. However, when fruit from different sizes had different initial ethylene production rates, those differences were maintained later in other phases of the ethylene production pattern.

143

Oxygen Consumption and Carbon Dioxide Production Rates

of 'Red Gold' Nectarines as Affected by Gas Composition and Storage Temperature

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The effects of gas composition and temperature on both the O₂ consumption (RRO₂) and CO₂ production (RRCO₂) rates of 'Red Gold' nectarines were investigated. Three temperatures (0, 10, and 20 °C) and six gas combinations of initial O₂ (1%, 5%, and 20%) and CO₂ (0 and 15%) with the balance N₂ were used. Triplicate glass jars containing two fruits each were flushed with the respective certified gas mixtures and stored in environmental chambers maintained at 0, 10, and 20 °C. Head space O₂ and CO₂ concentrations were monitored until O₂ levels dropped to 1% or less. Both RRO₂ and RRCO₂ showed significant increases ($P < 0.05$) as temperature increased from 0 to 20 °C at the gas concentrations tested. The RRO₂ increased slightly ($P < 0.05$) as initial O₂ concentration increased while showing no changes at the range of initial CO₂ concentrations used in the study. For RRCO₂, no significant changes ($P < 0.05$) were observed as gas concentrations varied at constant temperatures. This information is useful in establishing empirical models for modified atmosphere packaging predictions.

144

Fruit Volatiles to Control Postharvest Rot of Stone Fruits and Pears

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Volatile compounds are ubiquitous in plants, giving fruits their characteristic aroma and flavor. There is increasing evidence that these compounds can protect plants from pathogenic organisms. In this trial ≈25 volatile compounds were tested for efficacy against *Monilinia fructicola* and *Penicillium expansum*. Both in vitro tests on agar plugs of actively growing pathogens and in situ tests on inoculated stone fruits and pears were conducted. The volatile compounds were grouped into three categories based upon fungicidal activity in vitro: highly effective (fungicidal concentration ≤100 M), moderately effective (fungicidal concentration between 100–200 M) and ineffective (fungicidal concentration >200 M). Highly effective compounds included: acetaldehyde, citral, 2-ethyl-1-hexanol, 2,exadienal, E-2-hexenal, 4-hexen-3-one, linalool, (E,E)2,4-nonadienal, E-2-nonenal, E-3-none-2-one, salicylaldehyde, and valeraldehyde. Moderately effective compounds included: (E,Z)2,6-nonadienal, propionaldehyde, terpinene, butyl acetate, E-cinnamaldehyde, hexanal, E-2-hexen-1-ol, Z-3-hexen-1-ol and isoamyl acetate. Ineffective compounds included: butyrolactone, ethanol, ethyl acetate, and methyl acetate. Effectiveness of the compounds varied with both strain and type of microorganism tested. Concentrations required for effective control were much higher when the compounds were tested on inoculated fruit. Phytotoxicity was a problem with some compounds.

145

Changes in Fruit Phenolic Composition and Antioxidant Capacity during Storage

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Ripe fruit of strawberry, raspberry, and highbush and lowbush blueberries were stored at 0, 10, 20, or 30 °C for up to 8 days. Total phenolic and anthocyanin content was measured at regular intervals during the storage period as well as the total antioxidant capacity, using the method of Cao et al. (Clin. Chem. 1995, 41/12 17391744). There were significant differences in all parameters among the species, and after storage. Across all species and storage treatments, the antioxidant capacity was correlated with the content of phenolics ($R = 0.77$) and anthocyanins ($R = 0.85$). Both species of blueberry had more than twice the antioxidant capacity of either raspberry or strawberry; antioxidant capacity of the highbush and lowbush blueberries did not change during storage. During storage at temperatures greater than 0 °C, anthocyanin content of raspberries and strawberries increased substantially, and this increase was accompanied by an increase in total antioxidant capacity. Since dietary antioxidants such as anthocyanin flavonoids have been suggested to have positive health benefits, postharvest anthocyanin formation

may have a desirable effect on the health quality of certain fruit.

146

Ethylene Inhibitor, 1-Methylcyclopropene, Delays Apple Softening

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Three apple cultivars, Jonagold, Ginger Gold, and Gala, were treated at harvest with "EthylBloc," a commercial formulation of 1-methylcyclopropene (MCP). The apples were sealed in a container and the compound entered the fruit as a gas. Apples were treated for 16 h at 22 °C. Fruit were then stored at 22 or 0 °C. In some cases fruit were retreated after 20 days. Overall MCP treated fruit showed less softening than untreated fruit. Soluble solids and starch iodine ratings were similar in all fruit. 'Ginger Gold' firmness was 85 N at harvest, and after 20 days at 22 °C it was 75 N in MCP-treated fruit and 53 N in the control. In addition, there were large numbers of rotten fruit in the control, but not in the MCP treated fruit. Fruit firmness in 'Gala' was ≈64 N in the control and 95 N in the MCP-treated fruit after 30 days at 22 °C. Treated and untreated fruits stored at 0 °C showed less difference in firmness than fruit stored at 22 °C. However, in 'Jonagold' fruit there was a 13 N difference in firmness between treated and untreated fruit after 2 and 4 months 0 °C storage.

147

'Ginger Gold': A Summer Apple with Storage Potential in CA

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'Ginger Gold' is a high-quality summer apple with potential for processing and fresh markets. Although summer cultivars typically exhibit poor storage quality, data from three seasons indicate that storage potential is high for 'Ginger Gold' in low-O₂ controlled atmosphere storage. In 1995, fruit harvested 25 Aug. (85N) were stored in air (0 °C), 3% O₂/ $<2\%$ CO₂ (0 °C) or 0.7% O₂/1% CO₂ (0 °C) for 4 or 7 months. After 4 months, firmness of fruit stored in air, 3% O₂ and 0.7% O₂ were 53N, 67N, and 80N, respectively. After 7 months, apples stored in air were soft (45N) and had excessive decay (55%), cracking (48%), and breakdown (61%). However, fruit stored in 0.7% O₂ were of good quality (76N, 4% decay, 4% cracking, and no breakdown). No low-oxygen injury occurred. Apples were harvested on 14, 21 and 28 Aug. 1996 (85N, 80N, and 76N, respectively) and stored in air (0°C), 1.5% O₂/1% CO₂ (0°C), 1% O₂/1% CO₂ (0 °C) or 0.7% O₂/1% CO₂ (0 °C). Soluble solids were (9.5 at harvest, with starch scores of 3.5–4.5. After 2 months in air the firmness began to decrease rapidly and after 4 months ranged from 49–62N. Apples stored for 4 months in CA (≤1% O₂) maintained firmness >70N. In 1997, fruit were harvested 14, 21, 28 Aug. and 4 Sept. (102, 96, 89, and 82N, respectively and 12–13.3 °Brix). After 4 months in CA, fruit were still of high quality (>83N, > 13.2 °Brix).

148

Ethylene Influences α -Farnesene Biosynthesis of Apples

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Ethylene (C₂H₄) production or ripeness of fruit at harvest have been shown to influence α -farnesene accumulation and superficial scald development of apples. Effects of a 15-hr treatment with 500 ppm C₂H₄ and 7.5 ppm 1-methylcyclopropene (1-MCP), or 10-min dip in 200 ppm aminoethoxy vinyl glycine (AVG) on C₂H₄ production rate (EPR), hexane-extractable α -farnesene content in the skin, head-space α -farnesene evolution using solid phase micro extraction (SPME), and in vivo α -farnesene synthase activity of 'Delicious' apples stored for 2 months at 0 °C were investigated. Compared to untreated fruits, AVG and 1-MCP treatments reduced EPR by 95% and α -farnesene content in the skin by 75% at day 6. C₂H₄-treated fruits evolved over 50% higher α -farnesene, but had reduced α -farnesene content in the skin and head-space. However, enzyme activity was marginally increased in C₂H₄-treated fruits.

149

Assessment of Relationships between Fruit Peel Nutrient Concentrations and Storage Decay Incidence in 'd'Anjou' Pear

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Fruit were sampled from 12 mature 'd'Anjou' pear trees at commercial

harvest in each of two orchards in the Hood River Valley in 1996 and 1997. In 1997, separate fruit samples were obtained from the upper and lower canopy of each tree. Fruit firmness and starch index were determined for each sample in 1997. Fruit peel samples were obtained from five (1996) and 10 (1997) fruit per sample, and peel N, P, K, Mg, Ca, Mn, Zn, Fe, Cu, and B concentrations (% dry weight) determined. The remaining fruit were drenched with a dilute solution of blue mold (*Penicillium expansum*) and placed in cold storage. Decay incidence was evaluated after 3 and 5 months. In 1996, with the exception of Ca, fruit peel nutrient concentrations were not correlated with incidence of storage decay. A strong negative correlation between fruit peel Ca concentration and blue mold incidence was present in the samples from one orchard in 1996. Fruit peel Ca concentrations varied with year, tree, and canopy location. Results from the 1996 and 1997 seasons will be presented.

83 POSTER SESSION 2E (Abstr. 150–158) Crop Production—Vegetable Crops

150

Trellised Field Production of Seedless Cucumbers

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Production of seedless cucumbers (*Cucumis sativus*L.) may offer small-scale vegetable producers an opportunity for a specialty product for a niche market. Field production studies for four years using commercially available cultivars and a trellis system utilizing readily available fencing materials indicate acceptable yields can be achieved if strict attention is given to pest control. Since the cultivars do not have genetic resistance to diseases, fungal and bacterial diseases can result in severe yield reductions. Management of insects, especially those vectoring bacterial diseases, will also be crucial in some regions. Although the cultivars tested were developed for greenhouse production, some can produce good yields of attractive fruit when grown in field culture.

151

Yield and Quality Evaluation of Zucchini and Yellow Squash Varieties

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In Summer 1997, zucchini (ZC) and yellow squash (YS) varieties were evaluated for yield and aesthetic qualities at the Rutgers Agricultural Research and Extension Center in Bridgeton, N.J. Only green ZC varieties and straightneck YS varieties were tested. These types are commercially acceptable to fresh markets in New Jersey. Trials included 15 ZC and 11 YS varieties from seven participating seed companies. Experimental design included two sites arranged in a randomized complete-block design with three replications. Site 1 included the ZC varieties and Site 2 included YS varieties. Squash plants were grown on raised beds with black plastic mulch and drip irrigation. Squash was hand seeded on 30 May and harvests began on 7 July. Pesticides and fertilizers were applied according to the 1997 Rutgers Commercial Vegetable Recommendations Guide. Plots were harvested, graded, weighed, and yield data recorded three times weekly: 12 harvests (over 4 weeks) for ZC and 15 harvests (over 15 weeks) for YS. Of the 15 ZC varieties, five expressed exceptional quality and highest yields: 'Spineless Beauty', 'Zucchini Elite', 'Select', 'XPHT-1776', 'XPHT-1777'. Statistics showed that yields for these five varieties and two other ZC varieties were significantly higher than other ZC varieties trialed. There were no statistically significant yield differences among the 11 YS varieties evaluated. Fruit color from ZC and YS was subjectively rated to classify fruit into three categories: Dark Green, Medium Green, Light Green for ZC and Golden, Pale Yellow, and Yellow-Green for YS.

152

Yield and Fruiting Span of Tropical Vegetable Crop Parwal in a Temperate Climate

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Parwal, *Trichosanthus dioica* (Roxb.), is extensively cultivated in several areas of India, with the state of Bihar leading in total acreage and yield. This

perennial cucurbit is a dioecious tropical vine producing small fleshy fruits used as a vegetable. The purpose of this study was to determine the total yield, duration of fruiting, and period of maximum yield of parwal for the middle Georgia climate. A ratio of one male to four female plants were established in 1995 on wire trellises (24.4 m long). Fruits from 16 female 4.65-m² trellis sections were harvested weekly during Summer 1996. Data on fruit number (FNO), fruit fresh yield (FFY), and fruit dry yield (FDY) were recorded. Plants produced fruits over a 15-week period starting at the beginning of July and ending at the middle of October. The last 2 weeks of August were the peak time of production for FNO (25 fruits/plant), FFY (687.1 g/plant), and FDY (72.2 g/plant). Mean seasonal fruit number was 190 fruits/plant, while seasonal fresh fruit yield and fruit dry yield were 5.0 and 0.5 kg/plant, respectively. Results of this study indicate that parwal is able to produce fruits over 3 months in middle Georgia's temperate climate and that maximum fruit production occurs during the second half of August.

153

Eggplant Variety Evaluation in West Central Florida

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Eggplant (*Solanum melongena*) varieties and advanced breeding lines were evaluated in a full-bed polyethylene mulch system during Spring and Fall 1997. Yield and horticultural characteristics were assessed for eight entries in the spring and 13 in the fall. Spring: Highest U.S. Fancy yield from the two earliest harvests was 9.6 t·ha⁻¹ from 'Kiko' with a mean fruit weight of 0.64 kg and 1% of the total harvested fruit as cull quality. Highest U.S. Fancy yield from all five harvests was 31.2 t·ha⁻¹ from PX 984 with a mean fruit weight of 0.50 kg and 16% cull fruit. Seasonal yields combining U.S. Fancy, U.S. No. 1, and U.S. No. 2 grades ranged from 11.4 t·ha⁻¹ for 'Special Hibush' to 47.3 t·ha⁻¹ for 'Neon', with four entries not significantly different than 'Neon'. Fall: U.S. Fancy yields from the two earliest harvests ranged from 0.5 t·ha⁻¹ for 'Oria' to 'Agora' (2.7 t·ha⁻¹). Five other entries were not significantly different than 'Agora' in early U.S. Fancy yield: 'Orient Express', 'No. 226', 'Neon', 'Ghostbuster', and 'Vernal'. Greatest U.S. Fancy yield for all six harvests was produced by 'Santana' with 25.7 t·ha⁻¹, with a mean fruit weight of 0.45 kg and 14% cull fruit. Seasonal yields combining all grades ranged from 17.1 t·ha⁻¹ for 'Machiaw' to 41.2 t·ha⁻¹ for 'Santana', with six entries not significantly different than 'Santana'.

154

Changes in External and Internal Quality Characteristics of Three Tomato Cultivars Grown at Seven Different Sowing Seasons

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Seasonal fluctuations of the physical and biochemical characteristics of three tomatoes, including two large-fruited and one cherry-fruited cultivars, were studied in seven different sowing time at an interval of 45 days. Seasonal variation were noted in the external and internal quality characteristics. The seasonal pattern of ripening exhibited a rapid first ripening during summer, followed by a progressive decline until the winter season. Fruits picked during early winter to spring had higher constituents compared to summer season. The fruits matured during the summer season showed higher accumulation of organic and ascorbic acid; but the crop duration was found to be shortened. On the other hand, the fruits matured during winter to spring season had higher firmness, soluble sugars and longer growing period. The lycopene synthesis was enhanced during spring to winter seasons. Of the climatic factors recorded, temperature is predominantly implicated in affecting tomato fruit quality. The results indicated that, firmness, total soluble solids and turning point of hue ($\arctan a^*/b^*$) act as the indicators of fruit maturity, and breaker stage is more appropriate stage of harvesting in all the seasons studied. But regarding nutritional value and appearance, and for fresh consumption, pink stage of ripening is the best for harvesting. In the present study, although cropping season and growing temperature differed widely, but the cumulative temperature (°C day; from flowering to maturation) difference among growing seasons was small, and most suitable harvest period was found to be around 1000 °C day. Thus, for consumption, marketing and transportation, the fruits availing around 1000 °C days cumulative temperature are congenial to be harvested.

155

Evaluation of Carrot Cultivars Over Multiple Locations for Suitability of Quality and Harvest Characteristics

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Fresh-market carrots (*Daucus carota* L. *sativus*) have only been produced on any significant scale in Georgia since the early 1990s. Because most of the southeast U.S. carrot production is on muck-type soils, production practices had to be established for carrot production on mineral soils. Included in the establishment of these practices was the evaluation of varieties to find those of suitable yield. Additionally, these varieties had to possess low bolting, sufficient quality, and produce a sufficient top to be harvested mechanically. Many of the varieties produced in western states were not suitable for production in Georgia. After several years of testing under experiment station conditions, plots were established on farms at three separate locations. Plantings were established 1 Oct. and 24 Nov. 1997 in Jeff Davis County and on 4 Nov. 1997 in Wayne County. Plots consisted of three twin rows on a 1.-m bed with 35 cm between twin rows. Plots were a minimum of 6 m in length. Normal fertility and cultural practices were used. Evaluations of external color, length, overall marketability, smoothness, and top sufficiency were made on 27 Mar., 8 May, and 30 May, respectively. A total of 36 varieties were examined in replicated plots. Although there were some differences in smoothness and color, there were greater differences among varieties for marketability, and particularly length and top sufficiency. Several varieties were identified that would be suitable for production in Georgia.

156

Artichoke: A New Crop for 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, our objective was to evaluate the artichoke as a new crop for this area. We planted one 5-ha plot with 'Esmerald'. The planting date was 18 Oct. 1996, and the distance between rows and plants were 1.0 m and 1.6 m (6250 plants/ha). During the first year of production, the first harvest was on 24 Mar. 1997, and the last harvest 10 May. There was a total of seven harvests, with a yields of 400 boxes/ha for table production and 23,000 heads/ha for industrial use. The was 497 dollars/ ha, which is very low compared with other vegetables crops.

157

Root Development of Bean (*Phaseolus vulgaris* L.) is Affected by Trifluralin Herbicide

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The objectives of this study were to investigate the effects of trifluralin (TRI) herbicide on plant vigor and lateral root growth of snap beans. Lexington silt loam soil, which had not been treated with herbicides for at least 3 years, was used in this study. TRI herbicide was mixed with appropriate amounts of soil in a cement mixer to provide a constant rate of 560 g ai/ha TRI. To simulate TRI herbicide incorporation, bands of treated and untreated soil were layered into 30 x 30 x 15 cm (vol 13,500 cm³) bottomless wood boxes. Treatments were 1) control, 2) 2.5-cm treated band placed 2.5 cm below soil surface (BSS), 3) 2.5 cm treated band placed 5.1 cm BSS, 4) top 5.1 cm with treated soil, or 5) top 7.6 cm with treated soil. 'Benton' snap beans were planted in each box and grown in the greenhouse for 25 days. Plant measurements made included plant height, leaf area, and fresh and dry weight. The root system of each plant was washed and roots arising from the hypocotyl, transition zone, and primary roots were counted. All roots from each box were combined, dried overnight at 100C and weighed. Plant top weight and leaf area were not affected by TRI treatments. Plants were shorter in all TRI treatments except where placement was banded at 5.1 cm BSS. More adventitious roots were produced on hypocotyls when TRI was applied in a 2.5-cm band at 2.5-cm BSS or in the top 5.1 cm of soil. Total root weight was lower and fewer lateral roots developed in all soil bands treated with TRI.

158

Tomatoes Remember being Brushed

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Tomato seedlings grown in close proximity elongate rapidly in a shade-avoid-

ance response. A daily touch stimulus can eliminate the extra growth associated with shade avoidance. Experiments to determine how the touch stimulus is integrated were performed on tomato seedlings grown in plug trays 22 mm apart, starting when two fully expanded leaves overlapped between plants to induce the shade-avoidance response. The standard touch stimulus was applied by brushing the surface of the canopy 10 times each morning with a piece of Styrofoam sheet. This treatment reduced the daily growth rate from 7.7 to 5.8 mm/day, but quadrupling the dose further reduced growth only slightly (J. Amer. Soc. Hort. Sci. 121:894). The ability of the plants to sum individual stimuli was tested by varying the interval between the individual strokes. Intervals of 0.01, 0.1, 1 and 10 min all produced the same growth response. Thus, the individual strokes were perceived as a single stimulus. Had they been perceived as separate stimuli, long intervals would have increased the response. There was no refractory period of insensitivity following the stimulus; that would have reduced the response at longer intervals. The height reduction was directly proportional to the number of days that the treatment was applied, indicating that each day of treatment reduced the growth rate for only 1 day (from 5.9 mm/day to 2.7 mm/day). Thus, brief stimuli are integrated during the day and expressed as a reduction of growth the next diurnal cycle.

83 POSTER SESSION 2F (Abstr. 159–171) Breeding & Genetics—Cross-commodity

159

Survey Of Carotenoid and Tocopherol Variability in Corn

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Recent investigations into carotenoid and tocopherol activity indicate that these antioxidants are associated with the prevention of cancer and cardiovascular disease. Both carotenoids and tocopherols can be found in corn. A replicated survey of 21 sweet and dent corn inbreds was conducted to determine qualitative and quantitative variability of carotenoid and tocopherol content and form in corn germplasm. Ears were harvested at 20 days after pollination (DAP) and frozen in liquid nitrogen to remove kernels. Lyophilized samples were extracted, then analyzed using a reverse-phase HPLC method developed in this laboratory to simultaneously identify and quantify the carotenoids: lutein, zeaxanthin, β -cryptoxanthin, α -carotene, and β -carotene, as well as the α -, δ - and γ - forms of tocopherol. The primary carotenoids in immature corn were found to be lutein, and zeaxanthin, with the γ form of tocopherol dominating. Mean values among the genotypes were observed to range from 0.6 to 20 and 9 to 30 mg/g dry weight for lutein and γ -tocopherol, respectively, suggesting variability among inbreds in genes regulating the metabolism of these compounds. From this data, parents have been chosen for the creation of two segregating F_{2,3} populations, which will be used to study genetic associations of these compounds. This survey also found significant variability in antioxidant compounds between IL731a and W6786 for which a saturated linkage map containing 94 probes has already been constructed. Genetic investigations of this population will be conducted in the near future. The observed genetic variability suggests the possibility of developing germplasm with enhanced levels of these chemoprotectant compounds.

160

Flavor Analysis of *rin/+* and Other Tomato hybrids and Inbreds Using Sensory and Chemical Methods

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Consumer dissatisfaction with commercial tomato (*Lycopersicon esculentum* Mill.) eating quality is well-known. An array of tomato cultivars were tested for overall flavor by experienced or trained taste panels over several seasons. Fruit were also analyzed for aromatic volatiles, soluble solids (SS), and titratable acidity (TA). 'Solar Set' was the most consistent cultivar for overall flavor, always ranking in the most preferred statistical group. Cultivars that were bred for increased firmness, either by crossing firm lines (ultrafirms) or that were heterozygous for the ripening inhibitor (*rin*) gene, tended to rank low in overall flavor and sweetness. Comparisons made included ultrafirm lines, *rin/+* hybrids with one to three backcrosses to the high-flavored parent of 'Solar Set' (Fla. 7060), Fla. 7060, and

'Solar Set' with two rin backcrosses. Experienced panel ratings were highest for Fla 7060 followed by the *rin/+* hybrids (in descending order of backcrosses to Fla. 7060), followed by the ultrafirm lines. SS and TA were highest in one ultrafirm (SS = 9.1, TA = 0.68) and lowest in one of the *rin/+* hybrids (SS = 6.3, TA = 0.37) while the rest of the samples showed intermediate values. Analysis of flavor volatiles showed Fla. 7060 to be generally higher in most volatiles compared to the ultrafirms and two of the *rin/+* hybrids. Significant differences were found for methanol, ethanol, 1-penten-3-one, hexanal, trans-2-hexanal, trans-2-heptenal, cis-3-hexenol, 2+3-methylbutanol, 6-methyl-5-hepten-2-one, 2-isobutylthiazole, and geranylacetone.

161

Variability for Starch Digestibility in Dry Bean (*Phaseolus vulgaris* L.)

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Undigested starch is a major contributor to gastrointestinal discomfort experienced from eating cooked dry beans (*Phaseolus vulgaris* L.). Plant breeders are interested in identifying genetic stocks of beans with highly digestible starch to use in food quality improvement programs. Before a selection program for starch digestibility can be initiated, genetic variability must be ascertained. Breeding lines and cultivars from several dry bean market classes were evaluated for their starch digestibility using a laboratory procedure involving the determination of total dietary fiber with 3-enzymes. Grinding raw and cooked beans using a mill with the same-size screen (either 40 or 60 mesh) resulted in larger particles in the raw than in the cooked bean sample and inflated the amount of indigestible starch in the raw bean samples. In an experiment in which cooked and raw beans were ground with different size sieves, we found that in order to obtain cooked and raw beans with comparable particle sizes (thus providing accuracy and reliability to indigestible starch determinations), the cooked beans should be ground and sieved through a 40-mesh screen, and raw beans through a 60-mesh screen. Navy bean was the market class with the most digestible starch ($\approx 10\%$). Black beans and kidney bean had the least digestible—starch $>15\%$. Manteca, a Latin American market class with a pale yellow seed coat, was similar in digestibility to navy beans. Although the evidence is anecdotal, Manteca beans are favored for their qualities of taste, texture, and good digestibility. The current research on indigestible starch appears to confirm the high digestibility, low-flatulence attributes of Manteca bean.

162

Estimation of Correlation Coefficients between 17 Quantitative Traits in Hazelnut

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Thirty-five hazelnut (*Corylus avellana* L.) progenies and 41 parent genotypes were used to estimate phenotypic and genetic correlation coefficients among 17 nut, kernel, and phenological traits from 1994 to 1996. Correlation coefficients were large and positive for nut size traits (nut length, width, depth, nut weight and kernel weight). Phenological traits (days of opening of female flowers, time of catkin elongation and leafing out) were also highly correlated. But most other traits were uncorrelated with each other. Plots of progeny means and individual seedling values were inspected to verify which data points to have bigger effect on coefficients. These results and their application in the OSU hazelnut breeding program will be discussed.

163

Marker-assisted Selection for Improved Emergence and Eating Quality in Sweet Corn

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Marker-assisted selection is proposed to be more effective than phenotypic selection in improving complex traits with low heritability. This study was designed to test empirically the efficiency of marker-assisted selection (MAS) vs. phenotypic selection (PS) in enhancing economically important characters in sweet corn using composite populations consisting of selected $F_{2,3}$ families from two populations. In previous studies in our laboratory, these segregating populations were developed and assayed for genes influencing sweet corn emergence and eating quality. The 214 $F_{2,3}$ families in the first population (W678su1 X IL731ase1) were classified

into three sub-populations according to segregation for the *se1* gene. Marker-assisted selection and phenotypic selection were applied on the two homozygous *sugary1* and *sugary enhancer1* sub-populations separately. The second population consisted of 117 $F_{2,3}$ families from the cross of Ia453sh2 X IL451bsh2. The genotypic selection was based on the polymorphism of five RFLP markers linked to QTL associated with significant effects on emergence and eating quality in the $F_{2,3}$ generation. Twenty percent of the families in each population with the highest and lowest genotypic scores and phenotypic performance values were selected to constitute the MAS and PS composites, respectively. Emergence was evaluated in four different environments in Illinois and Wisconsin, while eating quality traits were evaluated in Illinois only. Results for emergence, with relatively high h^2 , in two out of three populations indicated that marker-assisted selection was superior to phenotypic selection. The effectiveness of MAS on enhancing stand establishment and eating quality will be discussed.

164

Molecular Markers Linked to Heat Tolerance of Broccoli

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A heat-tolerant broccoli cultivar was derived from the cross between two inbred lines. One inbred line of S7 is selected from a local cultivars in southern Taiwan, and the other of S6 is from the progenies of hybrids between broccoli and white flowering kale. The heat tolerance of this cultivar is believed to be inherited from the white flowering kale, which has been grown in southern Taiwan for a long period of time and has the characteristic of heat tolerance. Several molecular markers that may be linked to the heat tolerance were identified and may be able to be used in the future breeding program of broccoli and its related varieties.

165

Molecular Tagging of Gummy Stem Blight Resistance in Watermelon

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The fungus *Didymella bryoniae* causes gummy stem blight (foliar phase) and black rot (fruit phase) in cucurbits. As resistance to other diseases have been incorporated into cucurbits, losses due to gummy stem blight have increased. Populations derived from crosses between a cultivated watermelon (SS-4), susceptible to the fungus *Didymella bryoniae* and resistant plant introduction accessions (PI 189225 and PI 272778) are used to detect molecular markers linked to gummy stem blight disease resistance. Genomic DNA was purified from primary leaves of watermelon seedlings before seedlings were inoculated with a spore suspension of the fungus. Disease severity was rated 4 days after inoculation. DNA bulked from resistant or susceptible BC seedlings was amplified to detect AFLP markers. Linkages between gummy stem blight resistance and AFLP markers were identified and should facilitate evaluation and selection of watermelon populations segregating for gummy stem blight resistance.

166

'Duplin' and 'Sampson' Southern Highbush Blueberries

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'Duplin' (NC 1852) and 'Sampson' (NC 2675) are southern highbush blueberry genotypes that bloom with 'Croatan', the predominant highbush cultivar in eastern North Carolina, and ripen with or slightly later than 'Croatan'. 'Duplin' appears to have flower bud hardiness similar to standard highbush cultivars when grown at intermediate elevations in the mountains of western North Carolina. 'Sampson' appears to be bud hardy primarily in the piedmont and coastal plain of North Carolina. Yield overall has been equal to or better than 'Croatan' and 'O'Neal'. Fruit size, color, picking scar, firmness and flavor are superior to 'Croatan'. Both 'Duplin' and 'Sampson' were found to be tolerant to stem blight caused by *Botryosphaeria dothidea* in greenhouse screening in North Carolina. 'Sampson' also appears resistant to *Botrytis* blossom blight in Oregon. 'Duplin' and 'Sampson' are recommended for trial as potential replacements for 'Croatan' in the commercial blueberry region of eastern North Carolina.

167

Development and Release of the Novel Near-oblate Butternut-type Squash Variety 'Butterbowl'

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'Butterbowl' (NE-RBN-4) is a novel, small-sized (0.8 to 1.36 kg), flavorful (sweet), early maturing (90–95 days), near-oblata butternut type winter squash variety (*Cucurbita moschata* Duch. Ex Poir). No Butternut squash variety is similar in shape to 'Butterbowl'. 'Butterbowl' (S₆) was derived from selfing a near-oblata open-pollinated S₄ line derived from a cross of two true breeding crookneck lines (allelic test) NE-BNCR-67-1-7 (mutant out of 'Butternut 23') X golden Cushaw (Agway Co.). Total fruit yield and fruit weight of 'Butterbowl' were nearly similar to Butternut 'Ponca'. The total fruit weight of 'Waltham' was greater than 'Butterbowl' in two out of four trials. The vining habit of 'Butterbowl' (1.7 to 2.0 m) is more compact than 'Waltham' or 'Ponca'. 'Butterbowl' is suitable for small gardens with limited space due to its compact plant habit. No crookneck fruit developed in 'Butterbowl' in all tests. 'Butterbowl' is resistant to bacterial spot, black fruit rot, and vine borer while it is moderately susceptible to powdery mildew. 'Butterbowl' fruit should be used for consumption up to 45 to 55 days after harvest because slight fruit shriveling occurs at that time due to moisture loss. The fruit cooks uniformly in a microwave oven due to its more uniform flesh thickness.

168

Early Nodulin Genes are Not Markers of the Capacity of Woody Legumes to Nodulate

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Knowing whether trees can develop nodules in which nitrogen is fixed is important for managing inputs during culture. Early nodulin genes, such as *ENOD2* and *ENOD12*, could function as molecular markers for the capacity to nodulate if they are conserved only in species that nodulate. Several nodulating species are known to possess these genes; but, their occurrence has not been studied among non-nodulating taxa, including *Cercis canadensis* L. (redbud), *Gleditsia triacanthos* L. var. *inermis* Willd. (honey locust), and *Gymnocladus dioica* (L.) C. Koch (Kentucky coffee tree). Our objective was to determine the relationship between the capacity to nodulate and the occurrence of putative *ENOD2* or *ENOD12* genes by probing the genomes of these non-nodulating species and the genomes of two legumes that nodulate, *Albizia julibrissin* Durazz. (silk tree) and *Laburnum alpinum* (Mill.) Bercht. & J. Presl (Scotch laburnum). *ENOD2* and *ENOD12* cDNA clones from *Glycine max* (L.) Merill (soybean) and *Pisum sativum* L. (pea), respectively, and cloned *ENOD2* PCR fragments from *Maackia amurensis* Rupr. & Maxim. (Amur maackia) and *Styphnolobium japonicum* (L.) Schott (Japanese pagodatree) were used as probes for Southern hybridizations. Sequences from genomes of silk tree, Scotch laburnum, honey locust, and Kentucky coffee tree hybridized to *ENOD2* probes on Southern blots. Putative *ENOD12* sequences were detected in the genomes of Scotch laburnum, redbud, and honey locust. Thus, we conclude that *ENOD2* and *ENOD12* can not be used as markers for the capacity to nodulate.

169

Heritability of Postharvest Longevity of *Antirrhinum majus* L. Cut Flowers

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Breeding for postharvest longevity of cut flowers has not been done to any great extent in spite of the potential benefits from reduced chemical preservative usage and increased popularity of cuts due to longer vase life. Some studies have reported broad-sense heritabilities for postharvest longevity of 36% to 46% and narrow-sense heritabilities of 0% to 38%. Postharvest longevity of cut flowers of *Antirrhinum majus* L. (snapdragon) inbreds range from 2 to 16 d with the F₁ hybrids intermediate at 8.1 d when evaluated in deionized water. It would appear postharvest longevity of snapdragon cut flowers should be a selectable trait. In an effort to determine narrow-sense heritability for postharvest longevity of snapdragon cut flowers, a generation means analysis was established using single-seed descent S₄ generation inbreds with postharvest longevity of 2 and 15 d. Plants were grown in greenhouses at the Univ. of Wisconsin, Madison, in August and harvested in Nov. 1997 for postharvest evaluation. Experimental design was a randomized complete block with 2 environments and 3 replications. Nonsegregating generations (P₁, P₂, and F₁) consisted of 10 plants per replication,

backcrosses 30 plants per replication, and the F₂ with 60 plants per replication. Data will be presented on narrow-sense heritability of postharvest longevity of snapdragon cut flowers.

170

Segregation for Double Spine Trait in Hybrids of *Microcitrus inodora*

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Several *Microcitrus* species are valuable as parents in breeding citrus rootstocks and scions because of useful characteristics, such as monoembryony, very short juvenility, short fruit maturation time, and resistance to *Phytophthora* and nematodes. The large-leaf Australian wild lime, *Microcitrus inodora* (F. M. Bail.) Swing., also possesses a trait that is generally undesirable in new hybrids, double axillary spines. Most F₁ hybrids between *M. inodora* and single-spine *Microcitrus* and *Citrus* species were observed to possess the double spine trait. In crosses of *M. australasica* (F. Muell.) Swing. x *M. inodora*, *M. papuana* H. F. Winters x *M. inodora*, and *M. warburgiana* (F. M. Bail.) Tan. x *M. inodora*, double spines were present in 80%, 81%, and 87% of the progeny, respectively. In hybrids of *Citrus* species with *M. inodora*, percentage of double spines varied from 43% in progeny from *M. inodora* x *Citrus aurantium* L., to 100% in progeny from *M. inodora* x *Citrus ichangensis* Swing. When double-spined hybrids of *M. inodora* were used as parents in crosses with other single-spined *Citrus* species or hybrids, progenies varied from 0 to 86% with double spines. The patterns of inheritance suggest that the double spine trait is controlled by an allele of a nuclear gene that is dominant and homozygous in *M. inodora*, but that one or more other independently segregating alleles are necessary for expression of the double spine trait in advanced generation hybrids.

171

Identification of a RAPD Marker Closely Linked to Fruit Color in Muscadine Grapes (*Vitis rotundifolia*)

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The major fruit color phenotypes in grapes are either white (including green, yellow, bronze etc.) or red (including pink, reddish) and black (including purple). Like other fruits, anthocyanin (Acy) pigments in the berry skin contribute to the colors of grapes. These water-soluble pigments are phenolic compounds as secondary metabolite and accumulated essentially in the epidermal cells of fruits. Seedling screening can be performed if a genetic marker for the fruit color is available. A F₁ population of 82 progenies derived from a cross of two muscadine grape (*Vitis rotundifolia*) cultivars, 'Summit' x 'Noble', was used for tagging the gene determining the fruit color. 'Noble' is a red grape while 'Summit' is white. Segregation of berry color in the F₁ population indicated that the red color is controlled by a single dominant gene. RAPD (Random Amplified Polymorphic DNA) technique and Bulk Segregant Analysis (BSA) was used for tagging the fruit color trait. A total of 350 oligonucleotide 10-mers were screened for polymorphisms between the red- and white-colored DNA pools (each pool consisted of seven individual DNA samples). Two RAPD fragments linked to the target gene were identified and one of them, a 650-bp fragment completely co-segregated with the 56 progenies of red berries, while the white fruit progenies were absent of the RAPD fragment. The cosegregation data clearly indicated that the 650-bp RAPD fragment is tightly linked to the red fruit trait. The marker DNA was isolated from the agarose gel, cloned, and sequenced. A pair of 18-mers and 20-mers flanking the RAPD fragment were designed based on the sequencing information. The RAPD marker was reamplified in red-fruited muscadine grapes with this pair of universal primers.

83 POSTER SESSION 2G (Abstr. 172–174) Irrigation — Woody Ornamentals/Landscape/Turf

172

Interaction of Irrigation Frequency and Container Drain Hole

Design on Growth of Three Nursery Crops

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Three replicate blocks were installed for high-, medium-, and low-frequency irrigation, providing the equivalent of 25 mm, 8.75 mm, or 5.5 mm of daily rainfall, respectively. For three ornamental plants potted in 2.5-L pots, three container designs were tested: traditional drainholes located at the base of the sidewall (0% water storage), drainholes raised on the sidewall to provide 20% water storage (based on a water-filled pot), or drainholes raised on the sidewall to provide 40% water storage. The experiment was a 3 irrigation frequency x 3 container design factorial treatment arrangement within a randomized complete-block design using 10 representative plants of each species within each of three replicate blocks. The largest *Ilex* 'Hetzii', *Rhododendron* 'Hino Crimson', and *Geranium* 'Claridge Druce' were grown using high-frequency irrigation with 0% water storage or using medium-frequency irrigation with 20% water storage. Geranium shoot weight was significantly less only when grown using low-frequency irrigation in containers with 0% water storage, or when grown using high-frequency irrigation in containers with 40% water storage. Of the three species tested, only *Ilex* 'Hetzii' grew roots below the level of the raised drainholes, with these roots exhibiting thickened, enlarged diameters.

173

Production of Bareroot Roses Using Underground Drip Irrigation

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The majority of rose producers in Kern County, Calif., use furrow irrigation to produce ≈50% of the rose plants in the United States. Two experiments were conducted to test the feasibility of producing bareroot roses using underground drip irrigation. Three rose (*Rosa hybrida*) cultivars, 'Dr. Huey', 'Manetti', and 'Pink Simplicity', were used in both experiments. In the first experiment, drip tape was placed at a depth of 10, 20, 30, or 40 cm. After one growing season, plants irrigated with drip tape at 10-cm depth produced less shoot and total dry weight than plants irrigated with tape placed between 20 and 40 cm. 'Manetti' was the most vigorous cultivar and produced ≈70% more shoot and total dry weight than the other two cultivars. In the second experiment, the plants of the three cultivars were spaced 15, 20, or 25 cm apart within the row and irrigated with drip tape placed at 20-cm depth. Total dry weight increased linearly with increased spacing of plants within the row. 'Manetti' and 'Pink Simplicity' produced higher shoot and total dry weight than 'Dr. Huey' plants.

174

Frequent Irrigation Increases Growth of Pot-in-Pot Sugar and Red Maple

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In Virginia, pot-in-pot production of shade trees is normally accomplished by growing bareroot whips in 56-L containers for two complete growing seasons (production cycles). This study monitored the growth of *Acer saccharum* L. 'Green Mountain' (sugar maple), a species with moderate growth rate, and *Acer rubrum* L. 'Franksred' (red maple), a species with a fast growth rate, under standard once-a-day irrigation regime (1X) and a cyclic three-times-a-day regime (3X). Equal daily volumes of water were applied under each regime. Height growth rate increased for sugar maples but decreased for red maples in production cycle two compared to production cycle one. Stem diameter growth rates remained steady for red maple, but increased slightly for sugar maple. A 3X irrigation regime increased stem diameter of red maples, but had no other effect on either species in year one. Height and stem diameter growth of both species were increased by the 3X treatment during production cycle two. This study indicates that the standard production period results in decreased growth in the second production cycle for red maple, but not for sugar maple. Growth rates can be enhanced with a 3X irrigation regime for both species in production cycle two. The 3X irrigation regime only increases the stem diameter growth of red maple in the first production cycle.

83 POSTER SESSION 2H (Abstr. 175–187) Crop Protection/Rowcovers/Mulches— Vegetable Crops

175

Evaluation of Herbicides for Control of Annual Weeds in Asparagus (*Asparagus officinalis*)

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This research was conducted under field conditions in 1993 with a cooperative farmer with the aim of evaluating the effects of herbicides for the control of annual weeds (pre-emergence). The herbicides and rates (a.i./ha) applied were: Diuron 2.4 and 1.2 L, Linuron 1.5 and 0.7 L, Metribuzin 1.4 and 0.7 L, Simazina 1.5 L, Trifluralin 1 L and Naptalam+ Bensulide 4+3 L and 2+2 L. Two check plots were also included, one free of weeds and the other with weeds. A randomized block design was used with four replicates. The experimental units were 4.5 x 10-m plots. Trifluralin showed 56% of control and Naptalam+ Bensulide exhibited 24% at both rates, while Diuron (97% to 100%), Linuron (87% to 96%), Metribuzin (96% to 100%), and Simazina (96%) showed the best controls with either doses; of these, Linuron at 0.7 L/ha registered the lowest control (87%). None of the herbicides evaluated showed any plant toxicity.

176

Plastic Mulch Color Effects on Light Micro-environment and Watermelon Plant Growth

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This study was conducted to evaluate the spectral properties of various colored plastic color mulches and to determine the effects of upwardly reflected light from the mulch surfaces on watermelon plant growth when differences in root zone temperatures are minimized. Two-week-old watermelon plants were grown with black mulch, red-painted mulch, SRM-Red mulch (Sonoco, Inc., Harsville, S.C.), and white mulch. Total light reflection ($58 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ in 400–700 nm) and red:far-red (R:FR = 0.44) of reflected light were lower in black mulch and highest in white mulch (634 and 0.92, respectively). Both black mulch and white mulch had same blue:red (B:R = 0.6) while white mulch had higher B:FR (0.58) in reflected light compared to black mulch (0.26). Reflective properties of red mulches were somewhat similar, and R:FR, B:R, and B:FR were 0.8, 0.2, and 0.18, respectively. However, SRM-Red mulch had highest total light ($355 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ in 400–700 nm) transmission through the mulch, and R:FR, B:R, and B:FR were 0.84, 0.28, and 0.23, respectively. Light transmission through the other mulches was non-significant. Watermelon plants grown with black mulch and red mulches had higher internode lengths compared to white mulch after 20 days. Further, plants grown under black had significant higher petiole elongation accompanied with higher dry mass partitioning to petioles, and lower partitioning to roots, stems, and leaves. There was no effects of surface mulch color on total plant dry mass or photosynthesis although plants with black had higher transpiration rate. This suggests the differential regulation of dry mass partitioning among plant parts due to mulch color. The similar plant responses with black mulch and white mulch to plants treated with FR or R light at the end of photoperiod implies the involvement of phytochrome regulation of growth due to mulch surface color.

177

Agronomic Evaluation of Different Watermelon Varieties (*Citrullus vulgaris* Sch.) with Fertigation and Plastic Mulch

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The cultivation of watermelon is profitable for producers because of its high price and demand in the export market to United States and Canada. The crop profitability depends on the suitable management and agronomic practices and the selection of variety of the plant based on its productive capability. This characteristic is a cornerstone for the success in the establishment and yield of the crop. The present study was conducted to determine the vegetative growth and production of variety improvement of watermelon under irrigation conditions and plastic

mulch. The experiment was established in a muddy-sandy soil with 7.6 pH. The varieties evaluated were: Charleston Gray, Peacock Improved, Peacock WR-60, Tatum, Sunshade, Jubilee, and Chilen Black. Results show that all varieties in relation to yield and quality of fresh fruit presented similar yield, Sunshade and Jubilee registered highest production with 39.9 and 37.3 ton/ha, respectively, of fresh fruit with characteristics for export and for national consumption of 19.5 and 15.1 ton/ha. They have higher economic value. In relation to agronomic characteristics, the results show that 'Tatum' was earlier to flowering at 36 days and begin the ninth node flower. The greater longitude of the main sprout was in 'Peacock Improved', with 4.8 m; in size of fruit in 'Charleston Gray', and 'Tatum' had the greater longitude and diameter of fruit, with 45.6 and 21.4 cm, respectively. The varieties presented a similar yield of fresh fruit; although there exists an economically significant difference for quality of fruit, presenting the greater profitability. 'Sunshade' and 'Jubilee' are the most promising varieties to improve the economy of the producers.

178

Effect of Planting Method, Mulch, and Rowcover Combinations on Yield and Fruit Quality of 'Earliqueen' Muskmelon

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Three techniques to enhance the development and yield of 'Earliqueen' muskmelon, including transplanting, plastic mulch, and rowcovers, were applied in all combinations to determine which practice or practices offered the most beneficial effects on early maturity, and total marketable yield. Using transplants (two true leaf stage) as opposed to direct seeding had the greatest effect on increasing early yield. Black plastic mulch also significantly increased early yield. Rowcovers did not provide an overall increase in early yield, although the highest early yield was achieved from the transplant/mulch/rowcover combination. Black plastic mulch had the greatest effect on total marketable yield. Transplanting also significantly increased total yield. A slight increase observed for rowcover treatments was not significant. The combination of transplanting/plastic mulch/rowcover produced the highest marketable yield of any treatment. Direct seeding combined with no mulch produced the lowest yields and the lowest percent of marketable fruit. Under the conditions of a prolonged, cool, cloudy spring, followed by a hot, dry summer, the use of transplants and black plastic mulch provided significant increases in marketable yield of 'Earliqueen' muskmelons. Rowcovers did not provide significant yield effects, probably due to low light levels during the early growth period.

179

Muskmelon (*Cucumis melo* L.) Responses to Floating Rowcover

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Two groups of *Cucumis melo* L. cv. Galia F₁ were seeded on 10 Jan. 1994. The first group was direct-seeded in a loam sandy soil and covered at the same time with perforated polyethylene floating rowcover. The other group was seeded in a nursery and the muskmelon seedlings were transplanted and covered by perforated polyethylene in 7 Feb. 1994. The experiment was conducted in the Complexe Horticole experiment station located 17 km southeast of Agadir in a randomized block design with four treatments and four replications. Floating rowcover increased minimal and maximal air temperatures by 0.92 to 2.43 °C and 3.71 to 6.99 °C, respectively. Ten centimeters deep, soil temperatures of covered treatments were higher by 0.35 to 0.57 °C and 0.71 to 1 °C at 7 AM and 4.30 PM respectively. Plant early yield recorded in the four treatments: transplanted muskmelon with floating rowcover, direct seeded muskmelon with floating rowcover, transplanted muskmelon without cover and direct seeding without cover was 2003.9 g, 1219.2 g, 500.9 g, and 60.6 g, respectively.

180

Effect of Mulch Type and Color on Honeydew Melon (*Cucumis melo* L.) Production in Western Mexico

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Recently, honeydew melons cultivation has spread greatly in the western Mexico for its high price and demand for export market to the United States, Canada, and Japan. Information on production systems of this melon type is lack-

ing. The present study was conducted to determine the effect of various mulches on yield of honeydew melon grown in tropical region. Treatments evaluated were: clear, white, brown, black, silver/black, and black/silver as plastic mulches colors and rice and corn straw used as organic mulches and bare soil as control. All polyethylene were of 125 thickness. These were arranged in a randomized complete-block design with four replications. 'Honey brew' (Sakata) hybrid melon plants were transplanted each 0.50 m as single on the center row on 27 Mar. Results show that the all polyethylene mulches, irrespective of color, were superior to rice, corn straw and bare soil in improving the number and weight of fruits and yield of honeydew melons. Among the mulch colors, clear plastic increased the number and weight of fruits in 34 and 0.727 g with respect to control. Yield was also enhanced by clear mulch with 226.05 kg, compared with organic mulches and the control with only 113.30, 111.50, 100.20 kg/plot of 10 m² respectively. Clear and black plastic completely suppressed the weed growth. Total soluble solids were also affected by the mulch type at the first harvest, the best content (more of 10.0%) was obtained with white and brown plastic mulches, and organic mulches, while that bare soil showed 8.05%. Organic mulches were found as a low-input alternative agricultural system for honeydew melons production.

181

Threshold Monitoring, Trap Cropping, and Aluminum Mulch Repulsion for Management of Cucumber Beetles on Cucurbits

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Three approaches to cucumber beetle [striped, *Acalymma vittata* (Fabricius)]; spotted, *Diabrotica undecimpunctata howardi* Barber] management on cucurbits were tested on 11 farms in Virginia. Visual counts of striped cucumber beetles/five squash plants were similar in 1996 (2.6 ± 3.1, max 16) and 1997 (3.1 ± 3.8, max 18), but counts on adjacent yellow sticky traps were higher in 1996 (11.5 ± 14.5, max 66) than in 1997 (4.9 ± 4.1, max 16). Correlation between visual and card counts was stronger in 1996 ($r = 0.66$) than 1997 ($r = 0.38$). Regression indicated that a threshold of five beetles/five plants was equivalent to 16 beetles/trap in 1996, but only six beetles/trap in 1997. On two peak count dates in Aug. 1996, trap crop squash cultivar NK530 had 10 beetles/sticky card, significantly higher than the three to seven beetles/sticky card on 'Seneca' and 'Scallop'. Similar trends were seen in visual counts in these plots. In 1997, 'NK530' also showed preferential beetle attraction over pumpkin cultivar Howden. On early squash in 1997, cucumber beetle counts on two June peak dates were higher on black plastic (40 and 23 beetles/trap) than on solid aluminum (eight and five beetles/trap) or black with aluminum strips (15 and 10 beetles/trap). Black plastic required 1.8 insecticidal applications compared to none for solid aluminum. There were no significant differences in cumulative yield, although yield at first picking was 38% less on aluminum. Premiums for lower pesticide use (25%) compare favorably with the \$102/acre added expense for aluminum plastic.

182

Banded Cucumber Beetle (*Diabrotica balteata* LeC.) Injury during Sweetpotato Development

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Banded cucumber beetle (*Diabrotica balteata* LeC.) larvae can cause significant injury to the sweetpotato [*Ipomoea batatas* (L.) Lam.] by boring small holes in the storage root. Often, these holes expand with development to produce crater-like scars. The objective of this research was to characterize the effects of *Diabrotica* injury to storage roots by simulating the injury through development. Deep (i.e., penetrating the vascular cambium) and shallow (i.e., not penetrating the vascular cambium) injuries were inflicted at 10-day intervals on 'Beauregard' sweetpotato commencing 35 days after transplanting (DAT) through 85 DAT in 1996 and 1997. Visual evaluation indicated significant healing of deep injury through 55 DAT, with the diagnostic cratered appearance more prevalent on storage roots injured at 35 and 45 DAT. Moreover, deep injury in early development (35, 45 DAT) significantly expanded in diameter and depth, reducing marketable yield. Significant healing of shallow injury was observed through 75 DAT. The results of this research can be used by growers and researchers to assess the stage of development in which *Diabrotica* injury occurred.

Use of Cover Crop Mulches in a Processing Tomato Production System

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Conventional processing tomato production in California relies on inputs of synthetic fertilizers, water, and tillage to achieve high yields. Recently, there has been interest in reducing off-farm inputs and increasing soil quality by reducing tillage and increasing organic matter. Thus, this experiment examined the use of cover crops and no-till tomato production. Experiments were conducted in 1996 and 1997 at two sites, Five Points and Davis, Calif. Winter-grown cover crops included barrel medics, subterranean clover, pea, vetch, triticale, ryegrass, oat, and fallow controls. Cover crop plots were divided into three parts and nitrogen fertilizer added at 0, 112 or 225 kg/ha. Cover crops were mowed, and 3 weeks later, tomatoes were no-till transplanted into each plot. Weed cover at all sampling dates was less than 5% on all plots at the Five Points site, with no significant differences among treatments. At Davis, weed cover was much higher, but was also not significant among treatments. Tomato yields were highest (93 ton/ha) on the fallow plots and lowest (58 ton/ha) on the barrel medic plots at the Five Points site. At Davis, tomato yields were generally very low due to competition from weeds. The barrel medic cover crops plots had the highest tomato yields at this site (34 tons/ha), with plots without cover crops having the lowest yields (12 tons/ha). Tomato yields were 18% and 29% higher when 112 kg/ha or 225 kg/ha of nitrogen was added, compared to no nitrogen.

184

Mulch Type Influences Yield of Fall Tomato

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Because of environmental concerns relating to the potential for surface runoff from plastic culture, the potential of six cover crops [pearl millet (*Pennisetum glaucum*), sorgham (*Sorghum bicolor*), cowpea (*Vigna sinensis*), buckwheat (*Fagopyrum esculentum*), soybean (*Glycine max*), and millet/cowpea combination] was compared to a plastic mulch for fall tomato production in 1996. All cover crops were chemically desiccated prior to tomato transplanting. The use of plastic mulch significantly increased early marketable yield; soybean or millet/cowpea mulch significantly reduced the production of large fruit. Total marketable yield of cover crop mulches except millet/cowpea was similar to that of plastic mulch. In 1997, full (0.9-m) and narrow (0.45-m) plastic mulched beds were compared to desiccated millet or sorghum mulches or straw mulch applied at planting. Early marketable yield was greatest for straw mulch. Total marketable yield of straw and both plastic mulch treatments was significantly higher than that for desiccated mulches. Width of the plastic mulched bed did not significantly affect total marketable yield.

185

Enhancing Earliness in Peppers using Rowcovers and Water-filled Tubes

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Vegetable growers around New York State are using rowcovers and earlier planting dates to produce early peppers, due to the higher prices received compared to the main season. However, high temperatures often achieved under the tunnels can contribute to blossom abscission of peppers. Water-filled polyethylene tubes, which are placed underneath rowcovers, have been shown to moderate temperatures under low and high tunnels. These tubes of water, placed between or as near to plant rows as possible, under the tunnel, absorb heat during the day and radiate heat during the night. Two tubes, clear and black, were compared for impact on earliness of two varieties of bell pepper. Both tubes were 12" flat diameter and filled with water to an 8" flat diameter. Each bed had two rows of peppers, with the water tubes placed down the center. White, perforated plastic was placed over hoops to create row tunnels. Air temperature measurements in the tunnels indicated that both the clear and black tubes decreased the daytime temperatures compared to the tubeless tunnels. The black tubes absorbed more heat during the day. At night, both tubes were equally effective at providing a slight warming of tunnel canopy temperatures. However, clear tubes kept soil temperatures warmer at night and reduced overall soil temperature fluctuations. The black tubes showed no advantage for regulating soil temperature. No significant differences were detected for total yield among different water tubes or cultivars.

However, clear tubes contributed to a 30% increase in early yields, compared to control or black tubes. Economics of water tube use in early pepper production will be presented.

186

Effects of Cover Crops and Tillage on Sweet Corn Production

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A split-plot factorial experiment examined effects of tillage and winter cover crops on sweet corn in 1997. Main plots received tillage or no tillage. Cover crops consisted of hairy vetch, winter rye, or a mix, and N treatments consisted of plus or minus N fertilization. Following watermelon not receiving inorganic N, vetch, and mix cover crops produced total N yields of ≈ 90 kg/ha that were more than four times greater than those obtained with rye. However, vetch dry weight yields (2.7 mg/ha) were only about 60% of those obtained in previous years due to winter kill. Following rye winter cover crops, addition of ammonium nitrate to corn greatly increased ($P < 0.05$) corn yields and foliar N concentrations compared to treatments not receiving N. Following vetch, corn yields obtained in tilled treatments without N fertilization equaled those obtained with N fertilization. However, yields obtained from unfertilized no-till treatments were significantly ($P < 0.05$) lower than yields of N-fertilized treatments. Available soil N was significantly ($P < 0.05$) greater following vetch compared to rye after corn planting. No significant effects of tillage on sweet corn plant densities or yields were detected. It was concluded that no-tillage sweet corn was successful, and N fixed by vetch was able to sustain sweet corn production in tilled treatments but not in no-till treatments. In previous years normal, higher-yielding vetch cover crops were able to sustain sweet corn in both tilled and no-till treatments.

187

Inhibition of Fungal Growth by Macerated Plant Tissues in a Closed Environment

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The U.S. Clean Air Act bans the use of methyl bromide after 2001. Consequently, the development of alternative methods for control of soilborne pathogens is imperative. One alternative is to exploit the pesticidal properties of macerated tissues of *Brassica* spp. This study tested the potential of several *Brassica* spp. for control of fungal pathogens. *Pythium ultimum* Trow or *Rhizoctonia solani* Kühn plugs on potato-dextrose agar on petri dishes were sealed in 500-ml glass jars (at 22 °C) containing macerated leaves (10 g) from one of six *Brassica* spp. Radial growth was measured 24, 48, and 72 h after inoculation. Indian mustard (*B. juncea*) was the most suppressive, followed by 'Florida Broadleaf' mustard (*B. juncea*). Volatile compounds in the jars were sampled with a solid-phase microextraction device (SPME) and identified by gas chromatography-mass spectrometry (GC-MS). Allyl isothiocyanate (AITC) comprised over 90% of the total volatiles measured from Indian mustard and 'Florida Broadleaf' mustard. Isothiocyanates were detected in jars with all plants except broccoli. (Z)-3-hexenyl acetate was emitted by all plants and was the predominant volatile of 'Premium Crop' broccoli (*B. oleracea* L. var. *italica*), 'Michihili Jade Pagoda' Chinese cabbage (*B. pekinensis*), 'Charmant' cabbage (*B. oleracea* L. var. *capitata*), and 'Blue Scotch Curled' kale (*B. oleracea* L. var. *viridis*). To assess the influence of AITC on radial growth of *P. ultimum* and *R. solani*, AITC was added to jars to give headspace concentrations of 0.10, 0.20, and 0.30 mg·L⁻¹ (mass of AITC per volume of headspace). Growth of both fungi was inhibited by 0.10 mg·L⁻¹ AITC. 0.20 mg·L⁻¹ AITC was fungicidal to *P. ultimum* although the highest AITC level tested (0.30 mg·L⁻¹) did not terminate *R. solani* growth. These results indicate that residues from some *Brassica* spp. may be a viable part of a soilborne pest control strategy.

83 POSTER SESSION 2I (Abstr. 188–192) Education

188

"The Greenhouse of the Future": Using a Sponsored Competition in a Capstone Course

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Horticulture students often lack practical experience integrating information from diverse sources to solve complex real-life problems. Capstone courses seek to remedy this by giving students an opportunity to demonstrate a range of workplace skills such as teamwork, effective communication, and critical thinking. Sponsored competitions provide educators with an active-learning framework into which the goals of a capstone course can be developed. In 1996 the U.S. Dept. of Energy and the Epcot Center announced the "Greenhouse of the Future" competition. The competition sprang from an interest by sponsoring agencies to promote the development of new environmentally sound technologies for greenhouse food production and was open to all U.S. undergraduate students. The competition encouraged the formation of interdisciplinary student teams under the direction of a faculty advisor and offered the winning entry a \$10,000 research grant and the opportunity to display the new technology at the Epcot Center in Florida. The M.S.U. entry focused on the development of season-extending energy retention systems designed for small greenhouses, production testing of cool-season, stress-tolerant crops such as Mesclun salad greens, and the use of an environmentally neutral growing system. Sponsored competitions present an important tool for achieving certain educational objectives and may be one way to help students think on a higher level. Encouragement and development of similar competitions within the green industry is needed. Competition guidelines, components of the M.S.U. winning entry, and integration of the competition into the capstone course "Greenhouse Management" will be discussed.

189

A Web Site as an Aid in Teaching the Identification Of Landscape Plants

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Web sites were developed as an aid in teaching landscape plant materials at Oregon State Univ. A three-quarter course sequence emphasizes identification of woody landscape plants by their scientific names and, when appropriate, variety or cultivar names. Different groups of plants are introduced in each quarter: deciduous (fall), conifers and broadleaf evergreens (winter), and flowering plants (spring). Approximately 160 plant specimens are introduced each term, first by photographic slides and then by tours through the campus and surrounding areas. Each course is supported by a separate Web site that contains an informational summary and several images of each plant introduced. There are about 600 plant images per site. Plants on the Web sites are listed alphabetically by scientific name with links to specific images of that specimen (e.g., plant habit, leaves, flowers, etc.). Particular morphological characteristics used in plant identification are sometimes labeled in the images and some links provide side-by-side comparisons to aid in distinguishing similar plants. Students are not encouraged to use the Web sites as the major device to improve their plant identification skills, but rather to rely on frequent examination of live specimens in landscape situations. The Web sites are viewed as supplementary supports, especially to assist students in comparing similar plants, to provide a convenient source of plant images specific to each course, to permit visual study during inclement weather and at night, and in reviewing course material.

190

Undergraduate Program Growth and Enhancement: The Results of Curriculum Assessment in Landscape Contracting

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Following a recent curriculum assessment effort involving faculty, students, and industry representatives, the Dept. of Horticulture at Penn State developed a strategic action plan for future growth and evolution of its landscape contracting program. Highlights of the plan include: establishment of a landscape management option with emphasis on weed, pest, and disease management, plant establishment and plant maintenance; refinement of an internship program; continuation of collaborative and experiential learning opportunities; and development of a course that addresses current issues in the landscape profession. Additional actions resulting from the assessment process range from the addition of a Spanish course to support for the establishment of a campus arboretum.

191

A World Wide Web Site for Teaching Vegetable Crops

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A teaching homepage was created on the World Wide Web at: <http://www.hort.vt.edu/faculty/welbaum/hort4764> to teach an introductory college level course on vegetable crops. The homepage was designed to be viewed using Netscape software. Reading assignments and class outlines are formatted as .pdf files and can be viewed using Adobe Acrobat Reader. This software can be downloaded from the homepage. The homepage is linked to additional pages entitled: "Course description," "Instructor," "Text and other printed reference material," "Class schedule and assignments," "Class related pictures," "Sample test questions," "Chat room," "Class project," "Other web sites of interest," and "Grading." Two-hundred pages of text and outlines describing production of vegetables using plasticulture, vegetable seed technology, vegetable production under protective cover, and other topics as well as descriptions of 28 individual vegetables are available through the homepage. There are more 500 pictures and descriptions of vegetables and vegetable crop production linked to this website. Students can be examined using a computer testing system call Whizquiz that grades and corrects each exam. A Chat Room allows discussion among students and the instructor. Discussion sessions can be conducted between students and guests at distant locations. Student term projects on a range of subjects relating to vegetable crops are linked to the homepage. Links are provided to over 25 other World Wide Web sites with additional information on vegetable crops. This teaching homepage has been used for two semesters and students' evaluation of the system will be provided.

192

The Use of a Multidisciplinary, Culturally Rich Web Site by Youth and Formal and Informal Educators to Increase Appreciation and Awareness of Plants and Other Cultures

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Throughout history, people have forged an intricate relationship with plants. As a result, ethnobotany, the study of this association between people and plants, has begun to receive great attention. Like ethnobotany, horticulture is a field of study that humans depend on to enhance and beautify their living and working environments. In order to promote the fields of horticulture and ethnobotany, a multidisciplinary, "plant-centered" web site about Asian Indian ethnobotany was assembled. Novel or unique plants were used to promote exploration of multicultural experiences that reflected the increasing diversity in today's formal and non-formal classrooms. The web site contained pictures, video and audio clips, experimental activities, links to other web sites, places to visit these plant specimens, and supplemental materials for individuals interested in conducting further scientific investigations. Seven ethnobotany units were developed: Vegetable Diversity, Healing Plants, Indian Staples, Sacred Plants, the Easel of Indian Textiles, Tastes of India, and Ceremonial Plants. Outreach programs were conducted in Ithaca-area schools and 4-H clubs to evaluate youth interest in the topics presented in the web site. This educational program allowed middle school students the unique opportunity to conduct a self-guided exploration of important Indian ethnobotanical plants, while gaining important and valuable horticultural experience in plant classification, structure, growth substances, propagation, and diseases. This program also provided important exposure for both youth interested in pursuing ethnobotany or horticulture as a future career and for those with no previous horticultural or ethnobotanical experience. In conclusion, this web site used a novel multicultural approach to allow youth to develop an awareness for plants in other cultures while cultivating appreciation of plants important in their own cultures.'

83 POSTER SESSION 2J (Abstr. 193–201) Propagation—Woody Ornamentals/Landscape/Turf

193

Micropropagation of Adult Red Maple and Sugar Maple

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Micropropagation studies were conducted to determine the best methods to achieve axillary shoot proliferation for adult *Acer rubrum* (red maple) and *A. saccharium* (sugar maple). The first experiment was conducted to compare the effects of 0.001, 0.01, 0.1 μM , 1 μM , and 10 μM thidiazuron (TDZ) using Driver-Kuniyuki-Walnut medium (DKW). The second experiment was conducted to examine the effects of DKW, Woody Plant Medium (WPM) and Long and Preece (LP) media in factorial combination with 0.01 and 0.1 μM TDZ. The third experiment was conducted to study the transfer timing (14 or 28 days) and the media solidification (agar-solidified or stationary liquid) on sugar maple. Both red maple and sugar maple explants on DKW with 0.1 μM TDZ produced the most and longest axillary shoots; however, sugar maple produced fewer axillary shoots than red maple. Red maple explants produced the most callus on DKW with 10 μM TDZ and the least on DKW with 0.001 μM TDZ. Sugar maple explants produced more shoots when explants were placed horizontally and transferred every 14 days than when placed vertically or transferred less frequently.

194

Shoot Regeneration from Rhododendron Leaf Explants and Callus

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Shoots were regenerated adventitiously from leaf explants and from callus to determine if there is any effect on somaclonal variation and tissue proliferation of the three rhododendron cultivars, Arctic Pearl, P.J.M. Elite, and Purple Gem. The focus of this paper is regeneration. Leaves from shoot cultures were placed on a pre-conditioning medium for 2 weeks containing 10 μM indolebutyric acid (IBA) and 50 μM isopentenyladenine (2iP) and then transferred to treatment media. The six media tested were 0.1, 1.0, or 10.0 μM thidiazuron (TDZ) or 25.0, 50.0, or 75.0 μM 2iP. All treatment media contained 10 μM IBA. Data were collected on shoot regeneration after 24 weeks. Shoot number increased with increasing levels of TDZ for 'P.J.M. Elite', but decreased with increasing concentrations of TDZ for 'Arctic Pearl'. Shoot number for 'Purple Gem' leaf explants was greatest when there was 1.0 μM TDZ in the medium. In another experiment, leaf explants were placed on the same preconditioning medium for 2 weeks as above and then transferred to three treatment media containing 0.1, 1.0, or 10.0 μM TDZ and 100 μM IBA. Callus was produced on leaf explants after 4 weeks, regardless of cultivar or level of TDZ. After 11 weeks, adventitious shoots regenerated from 'Purple Gem' callus regardless of level of TDZ and from 'Arctic Pearl' callus when the medium contained 0.1 or 10.0 μM TDZ. After 11 weeks, there were no visible shoots on 'P.J.M. Elite' callus.

195

Epicormic Shoot Forcing of Adult Red Maple, Sugar Maple, and Eastern Black Walnut

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Dormant stem sections from three individuals each of *Acer rubrum* (red maple) and *A. saccharium* (sugar maple), and three clones of *Juglans nigra* (eastern black walnut) were collected from lower lateral branches of trees at least 30 years old. The stem sections were cut into 50-cm-long segments and placed horizontally in soilless media in a greenhouse. Two experiments were conducted to determine which treatments were most efficient for the production and elongation of epicormic shoots from latent buds below the bark. The first experiment consisted of a factorial arrangement of two levels of shading (not shaded or covered with 48% Saran shade cloth) and two levels of flooding (not flooded or flooded to a depth of 1/3 to 1/2 the diameter of the stem sections). Flooded treatments contained 0.025% NaClO to control microbial growth. The second experiment consisted of three media treatments: perlite, vermiculite, or a 1 perlite: 1 vermiculite (by volume) medium. No stem segments of any species in flooded treatments produced softwood shoots. Neither shading nor media treatments affected shoot number or length for any of the species. Additional sugar maple segments collected after budbreak produced more and longer shoots than those collected while dormant.

196

Axillary Shoot Proliferation of Adult Eastern Black Walnut

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Softwood shoots of adult *Juglans nigra* (eastern black walnut) were forced from latent (epicormic) buds below the bark of large stem sections in a greenhouse. Once sufficiently long, the shoots were excised, surface-disinfested, and cut into 1-cm-long nodal or apical segments for establishment in culture vessels. Two experiments were conducted, each using explants of three different clones. The first experiment compared the effect of cytokinins: 0.3, 1.0, or 3.0 μM benzyladenine (BA) and 0.1, 0.3, or 1.0 μM thidiazuron (TDZ) arranged factorially. The basal medium was agar-solidified Long and Preece (LP) with 0.05 μM indole-3-butyric acid (IBA) and 30 g/L sucrose. The second experiment compared the agar-solidified basal media: Driver-Kuniyuki-Walnut (DKW), Woody Plant Medium (WPM) and LP, all with 1.0 μM BA, 0.3 μM TDZ, 0.05 μM IBA, and 30 g/L sucrose. Regardless of the BA concentration, explants on media containing 0.1 μM TDZ produced few, if any, axillary shoots while explants on media containing 1.0 μM TDZ excessive amounts of callus. Explants in media containing 0.3 μM TDZ, at all levels of BA, produced the greatest number of shoots and minimal callus. Male catkins were produced by 17 explants on various media. Fifteen of the catkin-producing explants were from one walnut clone. Axillary shoot number and callus production were not significantly affected by basal medium for any of the three clones.

197

Tumor Incidence and Shoot Morphology Differences in Rooted Cuttings from Rhododendron With and Without "Tissue Proliferation"

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Tissue proliferation (TP) occurs in *Rhododendron* and is characterized by basal tumors that often develop numerous dwarf shoots. Growers need to know if the TP condition will persist in plants grown from normal-appearing cuttings collected from plants with TP tumors. Cuttings of seven cultivars were collected from plants with TP [TP(+)] and without TP [TP(-)] and rooted. Plants were grown in containers outdoors for a minimum of 2 years. For all cultivars, plants grown from TP(+) cuttings had more leaves per growth flush than plants grown from TP(-) cuttings. Shoots of TP(+) plants were either similar in length to shoots of TP(-) plants, or were shorter, as was the case for 'Boule de Neige', 'Catawbiense Album', and 'Montego'. 'Montego' and 'Scintillation' TP(+) leaves were shorter, narrower, had smaller leaf areas and larger length to width ratios than leaves from TP(-) shoots. No difference in leaf size and shape were detected for other cultivars. TP tumors were not observed on any plants. Another study examined the effect of stock plant age from tissue culture on development of TP symptoms in rooted cuttings. 'Montego' plants grown from cuttings collected from microplants, 3-year-old TP(+) plants, 6-year-old TP(+) plants and TP(-) plants were compared. Plants grown from 6-year-old TP(+) and TP(-) cuttings did not develop tumors. 83% of plants from microplant cuttings and 74% of plants from 3-year-old TP(+) cuttings formed tumors. Plants from microplant cuttings were more likely to develop large tumors that surround half or more of the stem than plants from 3-year-old TP(+) cuttings.

198

Utilization of Different Seedling Explants for in Vitro Propagation of Hibiscus syriacus

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Hibiscus syriacus is a difficult species in micropropagation due to its endogenous contamination and recalcitrant shoot formation; therefore, studies on using explants other than shoot tip or axillary buds of growing shrubs were initiated. Three different seedling fragments (root, hypocotyl, and leaf petiole) from aseptically germinated seedlings of hibiscus (var. Aphrodite) were evaluated for adventitious bud formation, shoot and leaf development. The explants were cultured on McCown's woody plant basal salt medium supplemented with KNO₃ (800 mg/L), adenine sulfate (80 mg/L) and MS vitamins containing BA or 2iP or TDZ at 0.5, 1.0, 2.2, 4.4 and 10 mM. Adventitious buds were present on all of the three different explants grown on medium containing TDZ; however, the most abundant bud formation, with many small leaves originating from callus was observed on hypocotyl explants cultured on medium with 1 mM of TDZ.

Petiole explants were the most frequent to develop short shoots (≈ 15 mm) and one to nine leaves without callus formation, where 70% of hypocotyl and the root explants formed leaves originating from callus. Callus was induced on all explant types regardless of the level or type of cytokinin used. However, the number of shoots produced by any explant type was low, petioles cultured on 0.5 and 1 mM of TDZ were the most suitable material for non-callus shoot development in *H. syriacus*. Hypocotyl explants proved to be an excellent source for adventitious bud formation but their ability to develop shoots needs to be investigated.

199

Somatic Embryogenesis and Plant Regeneration of Wiregrass (*Aristida stricta*) and Creeping Bluestem (*Schizachyrium scoparium* var. *stoloniferum*)

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Initiation of callus and induction of embryogenesis were achieved from both wiregrass and creeping bluestem. MS basal medium containing coconut milk, sucrose, and 2,4-D were used to initiate callus from young inflorescence of wiregrass and creeping bluestem. The presence of 2,4-D was found to be essential for the induction and early development of embryoids, possibly up to the globular stage. In the case of bluestem, initiation of embryogenic callus required the presence of a low concentration of BA; using only 2,4-D resulted in more non-embryogenic callus. More globular embryos were formed when embryogenic cultures grew rapidly without subculturing, or after being transferred to a hormone-free or a reduced 2,4-D medium. Plant regeneration was carried out in a hormone-free MS medium. Initiation of cell suspension and induction of embryoid formation of wiregrass were achieved. However, maintaining cell suspensions seems to have some problems. A majority of the cells were thick-walled, elongated, and non-dividing. No embryos were formed in suspension cultures planted onto solid media. Reinitiation of cell suspension culture of wiregrass is in progress. Initiation of creeping bluestem cell suspension culture was carried out in MS basal medium containing coconut milk, sucrose, and 2,4-D. The maintenance of the cell suspension cultures and induction of embryoid formation were tested under different combinations and concentrations of growth regulators. Suspension cultures were selected and planted onto semi-solid MS basal medium with or without growth regulators. Somatic embryoids formed from suspension culture 3 to 4 weeks after being planted on semi-solid medium. Germination and plant regeneration of somatic embryoid of creeping bluestem are in progress.

200

Propagation of *Alnus maritima* [Marsh.] Nutt. (Seaside Alder)

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We are interested in the potential of seaside alder as a shrub or small tree for managed landscapes. This species has received little attention from horticulturists and occurs naturally only in small, disjunct populations in Maryland and southern Delaware (Delmarva Peninsula), northwestern Georgia, and south-central Oklahoma. Our objective is to optimize asexual (softwood cuttings and tissue culture) and sexual propagation of seaside alder while testing for differences in propagation success among populations. Terminal softwood cuttings collected 11 June 1997 (Delmarva) and 25 Aug. 1997 (Oklahoma) were treated with IBA at various concentrations and provided intermittent mist in a greenhouse for 10 weeks. Up to 44% rooting was achieved by using 1 g IBA/kg on cuttings from Delmarva; replication over time will be used to determine whether poorer rooting of cuttings from Oklahoma (maximum of 17% with 8 g IBA/kg) was due to genotypic effects or the time of collection. Strobili were collected during late 1997 from multiple plants in the three populations. Unstratified seed from Oklahoma showed from 40% to 76% germination after 21 days depending on the tree of origin. The only previous data of germination of unstratified seeds was a report of 5% to 20% for seeds from Delmarva, so provenance as well as stratification effects on germination are being evaluated.

201

Mitotic Activity Dynamics in Recalcitrant Seeds *Acer sachharinum* during Maturation and Germination

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In orthodox seeds the cell division within the embryo meristems arrests during maturation at embryo moisture content (MC) 65% to 47%, and the maturation completion and transition of seeds to quiescent state occurs at MC about 10%. The arrest of cycling happens asynchronously in different meristematic tissues during desiccation: first in shoot and then in root. The aim of this work was to define a mitotic activity dynamics in recalcitrant seeds with the high MC at maturation end and the absence of quiescent state characteristic of it. The object was seeds of *Acer sachharinum*, using widely for planting of greenery in Kiev city. The mitotic activity was determined in 0.5 mm of the embryo root pole (RP) and 0.5 mm of the shoot pole with embryo leaves (SP). The *A. sachharinum* seeds completed their maturation at MC 53% (FW basis). During maturation the mitotic index (MI) in RP decreased from 3.2% in immature seeds (at embryos MC 80%) to 0 in mature seeds and in SP—from 5.4% to 3.3%, respectively. Cell division in SP arrested by dehydration of mature embryos to MC 46% by PEG 6000 (30%). The seeds lost viability by desiccation to MC 34%. The mature seeds were able to germinate immediately after abscission. During seed germination the cell division reactivated in RP and increased in SP already before root protrusion. In plantlets 10–15 mm long the MI increased to 8% in RP and 12% in SP. Thus, the strategy of immediate germination of recalcitrant *A. sachharinum* seeds includes a preservation of cell division in SP of mature embryos, in contrast with orthodox seeds, and high mitotic activity levels in meristems of germinating embryos before and after root protrusion.

83 POSTER SESSION 2K (Abstr. 202–208) Crop Physiology/Environmental—Cross-commodity

202

Growth of Ornamental Plants in Compacted Soils in Relation to Root Growth under Low Oxygen and High Atmospheric Pressure

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In urban situations, particularly after construction, herbaceous ornamentals may be planted into soils that are compacted or have poor structure so that plant roots may encounter poor aeration or physical resistance. Low oxygen concentrations may be the most important aspect of poor aeration and are readily reproduced in the laboratory. High atmospheric pressure might be used to screen for the ability to grow against physical resistance. We tested the suggestion that "native" plants would grow better in compacted soils than typical bedding plants and for differences in tolerance to low oxygen or high pressure. Plants were grown from seed in the greenhouse at four levels of compaction in peat-based medium and in field soil. Shoot dry weights of the native plants *Asclepias tuberosa*, *Echinacea purpurea*, and *Schizachyrium scoparium*, were less affected by growth in compacted soil or peat medium than those of the bedding plants, *Antirrhinum majus*, *Gypsophila elegans*, *Impatiens balsamina*, *Tagetes patula* and *Zinnia elegans*. The oxygen content of media declined with compaction to a minimum of 10 kPa. Half maximal root elongation was observed at 1 to 3 kPa oxygen for most species without any separation between the groups. A pressure of 1100 kPa reduced root elongation of the bedding plants by 50 to 70% but only 5 to 20% for the native plants.

203

Establishment of Prairie Forbs and Grasses after Production in Compacted Media

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Native prairie plants are believed to grow better in compacted soils than traditional bedding plants. We used 10 species of forbs and grasses to test the hypothesis that establishment in the field would be improved by greenhouse production of seedlings in compacted media and in topsoil as opposed to a peat-based medium. Media were compacted by applying 50 g·cm⁻² while filling cells in a tray. Uncompacted controls were simply loose-filled. The seedlings were transplanted into plots that were untilled or tilled. Plants were photographed with a digital camera at different stages and the images were analyzed by computer

to estimate growth non-destructively. At the time of transplanting estimated area per seedling was 15 to 140% higher for plants grown in compacted media than in uncompacted for 10 out of 13 species. Preliminary observations indicated that differences between plants from compacted and uncompacted media persisted in the field and that plants grew better in the tilled plots than in untilled. Seedling area was similar after production in topsoil or peat medium and there was no overall difference in the field. Plants from seedlings produced in topsoil were larger than those from peat-based medium in untilled plots but the converse was true for plants in tilled plots.

204

Effects of Sucrose and Oxygen on Nitrate Reductase Activity and Growth of Kentucky Bluegrass

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Nitrate reductase activity (NRA) in turfgrass roots should play an important role in the N metabolism of the whole plant because a major part of the shoots is removed by mowing. However, preliminary experiments demonstrated a lack of in vivo NRA in roots of Kentucky bluegrass grown in Hoagland's nutrient solutions, which were constantly aerated. We hypothesized that O₂ inhibited NRA by oxidizing carbohydrate available for NO₃⁻ reduction in roots. To test this hypothesis, Kentucky bluegrass (*Poa pratensis* L.), cultivar Merit, was grown in nutrient solutions containing 0.1 mM NO₃⁻. Grass cultures were treated with +O₂ (solution aerated), -O₂ (not aerated), +Suc (sucrose added to solution, final concentration = 25 mM) or -Suc (not added) for 12 days. Plants were harvested at 5:00 pm, separated into shoots and roots, and analyzed for in vivo NRA. The results partly supported the above hypothesis because the -Suc-O₂ roots showed significantly higher NRA than -Suc+O₂ roots. However, +Suc roots did not exhibit greater NRA than -Suc roots, possibly because of a decreased pH in the solutions. Oxygen increased root growth and hence the growth of the whole plant, while sucrose decreased leaf N content and leaf NRA but did not improve growth.

205

First-year Growth Response of Ornamental Trees to Municipal Wastewater Application

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The U.S.-Mexico border region has experienced rapid population growth in the past 30 years, resulting in natural resource degradation and declining public health. Many U.S.-Mexico border municipalities have inadequate systems for dealing with their waste. A major concern is the threat posed by water pollution, particularly that caused by minimally treated and improperly disposed human wastes. Border wastewater systems need to reduce contaminants, as well as safely recycle nutrients. Existing technology supports the land application of wastewater to tree production for low-cost, low-technology wastewater purification. Chemical analyses of the wastewater has shown that the water possesses an EC of 2.7 to 3.0 dS/m and an SAR of 6 to 7 indicating both high total salinity and sodicity that are potentially damaging to most woody horticultural crops. This project, located in Ojinaga, Mexico, assesses first-year growth characteristics and survival of three fast-growing trees useful for pulpwood production, *Eucalyptus camaldulensis* (three clones), hybrid *Populus* spp. (three clones), and *Robinia pseudocacia* (seedling propagated) following application with saline wastewater. Significant variation in trunk cross-sectional area was exhibited among clones. *Eucalyptus* clones showing the greatest increase in trunk area growth also exhibited ≈80% dieback during the winter months. Preliminary data indicated that one of the *Populus* clones may be the best option for effective wastewater treatment and economic sustainability through the sale of pulpwood for Ojinaga and other U.S.-Mexico border communities.

206

Growth, Morphology, and Physiology of *Intsia bijuga* Trees Under Varied Light Conditions

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Six studies were conducted with *Intsia bijuga* seedlings to determine the methods and extent of shade tolerance for this species. Growth differences were minimal among plants receiving varied light exposure, although treatments ranged from 19% to 100% sunlight exposure. Light saturated photosynthesis of leaves on plants receiving 24% sunlight was achieved at a photosynthetic photon flux

(PPF) of about one-fourth of that for the leaves on plants receiving 100% sunlight exposure. However, photosynthesis under conditions of extremely low PPF was higher for shade-grown plants than for full-sun plants. Shaded plants exhibited lower dark respiration, light compensation point, and light-saturated photosynthesis than full sun plants. Leaflet thickness, palisade layer number, and stomatal density of leaves of shaded plants were reduced compared with full sun plants. At seedling emergence and for several months thereafter, the plants responded to shade primarily with obligate sun plant characteristics. After the plants were established, however, responses to the varied light conditions indicated facultative structural and physiological characteristics.

207

Fatty Acid Concentration in *Portulaca oleraceae* L. is Altered by Photosynthetic Photon Flux

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Purslane (*Portulaca oleraceae* L.) seedlings were grown under an instantaneous photosynthetic photon flux (PPF) of 299 or 455 μmol·m⁻²·s⁻¹ for a daily duration of either 8, 12, 16, or 20 h. Thus plants were exposed to a daily PPF of 8.6, 12.9, 17.2, and 21.5 mol·m⁻²·d⁻¹ in the low PPF treatment (299 μmol·m⁻²·s⁻¹) and 13.1, 19.7, 26.2, and 32.8 mol·m⁻²·d⁻¹ in the high PPF treatment (455 μmol·m⁻²·s⁻¹). All treatments received a 20-h photoperiod using a PPF of ≈5 μmol·m⁻²·s⁻¹. At low PPF, purslane grown under 16-h PPF duration produced the highest concentration of total fatty acid (TFA), linoleic acid (LA), and linolenic acid (LNA) per unit leaf dry mass (DM) and leaf area; but at high PPF, the concentration of these compounds was highest under 8- and 12-h PPF duration. Trend analysis indicated that maximum TFA, LA, and LNA concentrations occurred with a PPF of 14.1, 16.9 and 17.2 mol·m⁻²·d⁻¹ respectively; and protein, chlorophyll, and LNA concentrations in thylakoid membranes were maximized at PPF of 21.8, 19.9, and 16.1 mol·m⁻²·d⁻¹, respectively. LNA as percent of TFA was unaffected by treatment. DM increased with PPF up to the highest PPF exposure of 32.8 mol·m⁻²·d⁻¹.

208

Sensitivity of Selected Vegetable and Weed Seedlings to Ultraviolet-B Radiation

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Relative sensitivity of selected vegetable and weed seedlings to ultraviolet-B (UV-B) radiation (280–320 nm) was investigated. Seedlings were grown for 4 weeks in a greenhouse, in chambers equipped with UV-B-emitting fluorescent tubes and Mylar (control) and cellulose acetate (UV-B) filters. UV-B radiation reduced seedling height, leaf area, and leaf fresh weight in tomato (*Lycopersicon esculentum* 'Cour Di Bue'), broccoli (*Brassica oleracea* var. Italica 'Purple Sprouting'), cabbage (*Brassica oleracea* var. Capitata 'Red Drumhead'), and cucumber (*Cucumis sativus* 'Straight Eight'), leaf area and leaf fresh weight in beet (*Beta vulgaris* 'Cylindra' and 'Early Wonder'), seedling height and leaf area in spinach (*Spinacia oleracea* 'Long Standing Bloomsdale'), lettuce (*Lactuca sativa* 'Red Salad Bowl Everest') and 'Savoy' cabbage, and seedling height in 'Chinese Tip Top' cabbage and lettuce ('Saladin'). 'Winterton' cabbage was not affected. UV-B radiation decreased leaf area and leaf fresh weight in common chickweed (*Stellaria media*) and corn spurry (*Spergula arvensis*) and seedling height in green foxtail (*Setaria viridis*) and redroot pigweed (*Amaranthus retroflexus*). Tillering was stimulated in response to UV-B in green foxtail. There was no effect of UV-B on lady's-thumb (*Polygonum persicaria*) growth. Leaf number was not affected by exposure to UV-B in any species. The differential morphological sensitivity of vegetable and weed seedlings may result in altered competitive relationships under enhanced UV-B levels expected with the depletion of the earth's ozone layer.

83 POSTER SESSION 2L (Abstr. 209–219) Crop Production—Herbs/Medicinals

209

Hydroponic Greenhouse Production of Fresh-market Basil in

Colorado

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Fresh-market basil has become a viable greenhouse commodity in Colorado. Marketing pressures and profit advantages also encourage the production of certified organic produce. The research objectives were to determine the length of time basil plants were productive in the greenhouse and to compare the production of fresh-market basil grown with three root zone systems and two fertilizer treatments. The three systems were hydroponic rockwool slab culture, hydroponic perlite raised bed culture, and hydroponic peat/perlite/compost bag culture. The two types of hydroponic fertilizer treatments were a salt-based formulated nutrient solution and an organic solution consisting of fermented poultry compost, hydrolyzed fish emulsion, and soluble kelp. The plants were harvested once per week for fresh weight determination. The results from the two runs show greater productivity for the plants in the perlite system as well as the bag mix system when fertilized with the organic fertilizer compared to salt-based fertilizer. However, productivity of the plants in the rockwool system was greater with the salt-based treatment compared to the organic treatment.

210

Nitrogen Fertilization of Basil

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Sweet basil (*Ocimum basilicum*) is an important culinary herb in Virginia and other areas. The objective of this study, conducted during 1997, was to determine optimal N rate for fresh and dry matter yield. Seed of Broad Leaf sweet basil were direct-seeded on 18 June in rows 0.75m apart in a RCBD design with 8 replications. Four N rates (0, 25, 50, and 75 kg N/ha) were used. Calcium nitrate (15.5% N) was used as the fertilizer source. All plants from 1-m row length from middle row of each plot were harvested by hand on 23 Sept. and fresh weights were recorded. The plant material was dried at 70°C for 48 h to record dry weights. The moisture content at harvest was calculated from fresh and dry weights. The fresh yields following 0, 25, 50, and 75 kg N/ha were 3.7, 5.4, 6.4, and 6.8 kg/m², respectively. The yield difference between two highest N rates was not significant, however, both these rates had significantly higher yield than the two lowest rates. Similar results were also obtained for dry matter yields. The highest N rate of 75 kg N/ha resulted in significantly higher dry matter yield (1.3 kg/m²) as compared to the other three rates. The lowest dry matter yield was obtained after the control treatment (0.6 kg/m²). An opposite relationship between N rate and moisture content was observed when the highest moisture content resulted from control and 50 kg N/ha treatments. These results indicate that optimum N rate for sweet basil in Virginia is 50 to 75 kg/ha.

211

Ethephon for American Ginseng (*Panax quiquefolium* L.) Inflorescence Removal

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Varying concentrations (500-4000 mg·L⁻¹) of ethephon, an ethylene-releasing compound, were applied to 3-year-old ginseng (*Panax quinquefolium* L.) plants in fields of southern Ontario. The effects of this chemical on fruit removal, plant damage, infructescence morphology, and root mass were studied and compared to the normal practice of manual inflorescence removal. The highest concentrations had the highest rates of removal but also caused the greatest amount of damage to the whole plants when compared to the mid-range concentrations. The lowest concentrations showed less foliar damage but did not provide sufficient fruit removal to mimic hand removal. When individual inflorescences of the ethephon treatments were studied, the seed heads had fewer ripe berries and more unpollinated florets than the untreated controls. When root masses were compared, high and low concentrations showed lower masses than those of the standard production practice of hand removal. However, mid range concentrations showed similar root mass increase to manual removal. When all parameters were considered, the concentration range giving the best results was 1000-1500 mg·L⁻¹. Multiple applications of ethephon, at weekly intervals, had an additive effect on flower removal and plant damage. Treatments having an additive concentration of over 2000 mg·L⁻¹ had detrimental effects on all parameters. Those within the 1000-1500 mg·L⁻¹ range showed the highest similarity to the hand removal benefits.

212

Inflorescence Removal Effects on Root Yield of American Ginseng (*Panax quiquefolium* L.)

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American ginseng is a perennial herbaceous plant grown for its fleshy root and seeds. Little is known about fruit set and development in ginseng. In commercial practice a small proportion of 2-year-old plants may bear flowers and seed but these seeds usually are not harvested. Seeds from 3-year-old plants are harvested and used for establishing plantings, but seed from 4-year-old plants, if available, are preferred. Some growers remove flowers manually from plants in June at an estimated cost of \$2500 per ha and claim higher root yields. The objective of this work was to determine the effect of inflorescence removal in 1 or 2 years on root yield. Manual removal of inflorescences from mature (3- and 4-year old) American ginseng plants at commercial timing (early July, ≈25% flowers open) increased root yield at harvest compared to plants where the inflorescences were retained. Consecutive inflorescence removal for 2 years (3rd and 4th) increased yields 55.6% compared to 34.4% for removal in one year only (4th). Root size distribution analysis showed that most roots (≈40%) were in the medium category (10-20g): inflorescence removal did not influence root size distribution. Root yield for 3-year-old plants increased quadratically with plant density with plants lacking inflorescences having an estimated yield increase of 25%. Maximum yields of 2.4 kg·m⁻² for deflowered plants were suggested at a plant density of 170 plants/m². To maximize ginseng root yield all plants should have inflorescences removed except those needed to provide seed for future plantings.

213

Growth, Opium Gum Yield, and Photoperiod Response in Five Opium Poppy (*Papaver somniferum* L.) Cultivars

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To develop models for estimating growth, flowering time and gum yield of opium poppy, we compared variability among five cultivars (T, L, B1, B2, B3) from different latitudes in three Southeast Asian countries. Variability in the relationships between gum yield, capsule volume, and dry weight was also examined. Plants were grown in six growth chambers at a 11-, 12-, 13-, 14-, 15-, or 16-h photoperiod (PP) with a 12-h 25/20 °C thermoperiod. The main capsule was lanced for opium gum at 10, 13, and 16 d after flowering (DAF). Plants were harvested at 21 DAF and separated into leaves, stems, and capsules. Flowering time for B2 was affected least by PP and B1 the most. Flowering times for B3, L, and T were similar across the range of PPs. All cultivars showed a significant increase in flowering time from 14 to 13 h PP. Cultivars that flowered late (such as B1) had greater biomass than those that flowered earlier. However, cultivars that flowered earlier (such as L) had more dry matter partitioned into capsule than late-flowering ones. B2, B3, and L had the highest gum yields while B1 had the lowest. Positive correlations were found between gum dry weight and capsule volume (or dry weight) for T and L, but no correlations were observed between these variables for B1, B2, and B3. Our results indicated that plant dry weight varied as much as 77% and flowering time varied up to 40% even though the critical photoperiod was the same for all cultivars. The ratio of gum yield to capsule dry weight were significantly different between B1 and T.

214

Toxic Metals in Different Varieties of Seabuckthorn (*Hippophae rhamnoides*)

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Seabuckthorn (*Hippophae rhamnoides*, L) (Oblepiha, Siberian pineapple, Sandorn, Sha-ji), from the Eleagnaceae family, is one of the most important and leading sources of pharmaceutical, nutritional, and cosmetic products in Tibet, Russia, and China. Hippophae oil is an important component of the cream for protection from cosmic radiation, tan-enhancing, cell tissue regeneration, wound healing, and antiaging properties. It is a good source of natural antioxidants, and is used to boost the body immune system, adaptation to extreme conditions, and increased performance body performance. The fruits, seeds, leaves, and cork contain a large amount of chemical elements, essential oils, vitamins A, B, C, E, carotenoids, flavonoids, palmitic and palmitoleic acids, unsaturated fatty acids, α-sitosterol, proteins, minerals, and many other bioactive compounds. As part

of the selection and genetic improvement program to develop superior varieties of higher fruit yield, quality and resistance, varietal difference in the uptake or accumulation of heavy (toxic) metals in the berries was investigated. The variation in the content or accumulation of Zn, Cu, Pb, Cd, and Fe in the berries of three varieties of Hippophae (Chuisakaja, Zivko, and Chechek) with differing morphological, and fruit quality was studied. The plants were grown under similar conditions, at Lisavenko Inst. for fruit trees research in Russia. There was a significant difference in the concentration of the metals among the three varieties. Variety 'Tchuisakaja' was found to have significantly higher concentration ($P < 0.05$) of Cu, Pb, and Fe. The lowest concentration of the metals was recorded for the variety 'Chechek'. The obtained results enable us to suggest, that the Hippophae varieties may significantly vary in the accumulation toxic elements in their berries. This fact should be well considered during selection and improvement program for Hippophae.

215

On the Standardization of Seabuckthorn (*Hippophae rhamnoides* L) Oil

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Seabuckthorn (*Hippophae rhamnoides*, L) (Oblepiha, Siberian pineapple, Sandorn, Sha-ji), a perennial from the Eleagnaceae family, has attracted the interest of North American natural products industry because of its effective multiple applications in cosmetic, nutraceutical, and veterinary industries. The oil obtained from the berries, bark, and leaves, and is known to contain carotenoids, vitamins, and essential fatty acids. The objective of this investigation was to elaborate and establish reliable, but inexpensive, methods in the process of standardization of the quality of oblepiha oil. Data of the phytochemical analysis of oblepiha oil obtained from various research reports and industrial and experimental sources, located in different parts of Russia (ex-USSR), were extensively investigated and statistically evaluated. An indirect method of standardization of oblepiha oil, based on the content of carotenoids and unsaponifiable fraction of the oil, has been proposed. The correlation between total carotenoids and unsaponifiable lipids in extracted oil of oblepiha ($r = 0.76$; $P \leq 0.05$) has been shown. The strong relationship between carotenoids, unsaponifiable lipids, and sterin fractions in the raw material and industrial oil indicates the possibility of using the level of total carotenoid concentration as a reliable and direct approach to indirectly determine the efficacy of oblepiha oil for nutritional, pharmacological, and cosmetic applications.

216

A Comparative Study of *Rhodiola rosae* under Cultivation and Natural Growing Conditions

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Rhodiola rosae L., from the Crassulaceae family, is a perennial widely known in Russian folk and official medicine for its adaptogenic properties. The extracts from the roots of *Rhodiola rosae* is known to be a better alternative to ginseng because of its better effects, safety for people having high blood pressure, cardiac and kidney problems, pregnancy, and minors. *Rhodiola* is collected mostly from the wild, and this practice has resulted in the decimation of the wild population in Altai mountains and in southern Siberia. The objective of this investigation was to find the best method of production and guarantee the availability of the raw material without compromising the quality. Plants were studied under naturally growing conditions and brought into cultivation. We used seeds to propagate. Morphological traits, flowering, leaf area, shoot and root yield, and content of salidroside (biologically active component in the root) were measured in 50 plants. The measurements were taken during the 1st, 2nd, and 3rd years of the cultivated plants, while parallel measurements were taken from the same place of naturally growing plants. Plants under natural conditions did not receive any agronomic treatment, while normal agronomic practices were given for plots under cultivation. We found significant difference in all measured parameters. Though higher root yield was obtained from cultivated plants, the concentration of salidroside was found to be higher naturally grown plants. With the increasing age of the cultivated plants, however, the concentration of salidroside significantly increased. The total yield of salidroside, g/m² was found to increase consistently each year for cultivated variants compared to plots under natural growth.

217

Development of *Thymus vulgaris* Varieties for North American Commercial Organic Cultivation

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Five different cultivars of *Thymus vulgaris* originating from various geographical sources (Canada, F.R. Germany, former GDR, and Spain) were first propagated by cuttings from each cultivar in the greenhouse and then cultivated organically in the fields during the periods of 1993–1995 (Quebec, Canada) and 1996–1997 (Washington State). The field-grown plants were harvested in mid-September. The oils obtained through steam distillation of the dried leaves from each cultivar were analyzed by means of TLC followed by GC. The oil content varied from 1.38% to 2.04% in Quebec, and 1.41% to 2.25%, depending on the cultivar used. The highest oil content was obtained from 'Madrid', followed by 'RH-1' and 'Laval-1'. More than 95% of the oil, with a total of 24 components, were identified in the samples. 'Laval-1', recently developed in Quebec, 'Madrid' from Spain, and 'RH-1' from Germany were established to belong to thymol-chemotypes, while 'RH-2' from Germany was found to be carvacrol-chemotype. 'QDLB', from the former GDR, was characterized by its ≈39% thymol, 17% carvacrol, and 3.52% linalool content in the oil. The content of thymol and its ratio was found to change slightly with shifting cultivation of the cultivars from Europe to North America. Other important constituents in the essential oils were also *p*-cymene (10.87–22.89%), *g*-terpinene (2.21–8.85%), α -pinene (0.87–2.23%), sabinene (0.00–1.77%), borneol (0.00–3.69%), geraniol (0.59–3.48%), and terpinen-4-ol (0.21–3.08%). As 'Laval-1' and 'RH-1' showed better overwintering ability and produced relatively higher leaf yields. These two cultivars were found to be prospective cultivars for commercial organic cultivation for North America. Results obtained from various growing areas are presented.

218

The Selection and Development of High-quality Echinacea for Industrial Processing

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Echinacea is one of the oldest medicinal plants that had been used by the native Indians of North America for bacterial and viral ailments. With the increasing scientific findings about the usefulness of Echinacea in natural immune stimulation of humans, the demand for high-quality echinacea product in natural food markets in the United States and Europe has been growing. However, most of the commercial supply of echinacea originates either from heterogeneous material or wild collections. Trout Lake Farm in Washington State is the leader in production and processing of echinacea. The objective of this investigation was to find and develop high-quality echinacea lines or cultivar for commercial biological production and processing. The variation in morphological traits, ripening period, the root and shoot yields, resistance to diseases and insects, and the content of active substances (cichoric acid, echinacoside, isobutylamides, and essential oil) in *E. purpurea* was carried out during the 1996 growing season. We found dramatic variations in plant height, color and size of the leaves, flowers and period of flower induction, yield, and the accumulation of the active substances.

219

Two Methods for the Rapid Assessment of Leaf Yields of *Erythroxylum coca* 'Coca'

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To determine the extent of world coca (*Erythroxylum*) production, methods for rapid estimation of yield (leaf mass) are required. The objective of this research was to compare two methods for rapidly acquiring data to estimate yield. The plant canopy analyzer (PCA) method was based on measuring canopy light interception with the LI-COR PCA, calculating leaf area index (L), and converting L to leaf dry weight using specific leaf area (SLA) values. The canopy subsample method was based on calculating leaf dry weight of a subsample from leaf and branch number, leaf size, and SLA, then multiplying by the ratio of the canopy volume to the subsample volume. PCA measurements underestimated leaf yields when values of L were ≥ 1.0 . PCA estimates could be corrected by adjusting for the observed difference between leaf yields and PCA estimates. The corrected PCA and canopy subsample methods had errors of similar magnitude, both slightly underestimating yield. Both methods performed well when tested against data from a subsequent harvest. The canopy subsample method uses simple equipment and can be ap-

plied in almost any environmental condition, but requires more time in the field than the PCA method. The corrected PCA method has slightly less random error than the canopy subsample method but requires expensive equipment, uniform light conditions in the field of view, and cannot be applied when raining.

83 POSTER SESSION 2M (Abstr. 220–227) Breeding & Genetics—Reproductive Biology

220

Characterization of the Reproductive Mode in Guayule In Vitro

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Guayule (*Parthenium argentatum* Gray, Asteraceae) is a latex-producing perennial desert shrub that is potentially of economic importance as an industrial crop for the desert Southwest. It is known to possess complex reproductive modes. Diploids are predominantly sexual and self-incompatible, while polyploids show a range of apomictic potential and self-compatibility. This paper describes the development of a relatively rapid and simple technique for characterizing reproductive modes of breeding lines of *P. argentatum*. Initial field experiments were based on an auxin test used successfully to characterize reproductive mode in the Poaceae. The application of 2,4-dichlorophenoxyacetic acid inhibited embryo formation in *P. argentatum*, but this was not the case with other auxins tested. Results of field experiments were ambiguous because: 1) the floral structure of *P. argentatum* is such that auxins might not have penetrated to the ovules, and 2) there was potential self-fertilization by pollen released within isolation bags. Therefore, in vitro culture of flower heads was tested because it provided much better control of environmental conditions, growth regulator application, and pollen release. Auxin alone, or in combination with gibberellic acid or kinetin, inhibited parthenogenesis in vitro. Embryo production did not vary using two substantially different nutrient media. In vitro flower head culture using a (Nitsch and Nitsch) liquid nutrient medium without growth regulators, enabled characterization of the reproductive mode of seven breeding lines, ranging from predominantly sexual to predominantly apomictic. The results of this technique were substantiated using RAPD analyzes of progeny arrays from controlled crosses.

221

Interspecific Crossability of Nine Diploid *Fragaria* Species

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As part of a wild species introgression program, *Fragaria vesca*, *F. viridis*, *F. nubicola*, *F. nipponica*, *F. nilgerrensis*, *F. pentaphylla*, *F. gracilis*, *F. daltoniana*, and *F. iinumae* were crossed in most combinations possible, the exceptions being *F. daltoniana* and *F. iinumae*, which produced only a few flowers each. Crosses with *F. vesca* as a female and either *F. gracilis*, *F. nipponica*, or *F. iinumae* as males produced good seed set, but seedlings died in the cotyledon stage in every case. No seed set occurred when *F. iinumae* was crossed with *F. viridis* or *F. nubicola*. *F. pentaphylla*, *F. gracilis*, and *F. iinumae* were observed to be self-incompatible while *F. daltoniana* was self-compatible. Three overlapping groups based on crossing data have emerged. Within the following groups, hybrid plants were obtained in all species combinations, although not necessarily for reciprocal combinations: Group A: *F. vesca*, *F. viridis*, *F. nubicola*, and *F. pentaphylla*. Group B: *F. vesca*, *F. nilgerrensis*, *F. daltoniana*, and *F. pentaphylla*. Group C: *F. pentaphylla*, *F. gracilis*, and *F. nipponica*. Fertile or semifertile diploid hybrids were obtained for all species combinations within group A indicating genomic similarity or that breeding at the diploid level could occur with these species. Fertility has not been determined for hybrids in groups B and C. It is interesting to note the presence of *F. pentaphylla* in all three groups, perhaps this species plays an important role in *Fragaria* evolution.

222

Reproductive Efficiency in Muscadine Grapes

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To determine the berry production efficiency of selected muscadine grape cultivars, pollen production, size, and viability; time of pistil receptivity; mode of pollination; number of flower per cluster; and percentage fruit set were studied. Each of 17 hermaphroditic cultivars except 'Noble' produced a high percentage of viable pollen grains. Pollen size averaged 32 and 51 μm in 2 years. Even at this small pollen size, our observations suggest insects rather than wind as the primary means of pollen transfer to pistillate flowers. Pistils were not receptive until the calyptra dehisced, thereby ensuring that pollen can reach the pistil when it is receptive. 'Carlos' produced 68.5 and 'Black Beauty', 'Doreen', 'Fry', 'Sweet Jenny', and 'Supreme' produced from 38 to 46 flowers per cluster. Percentage fruit set ranged from a high of 22 to 34 for 'Fry', 'Sweet Jenny', 'Doreen', and 'Supreme', and a low of 12 to 14 for 'Carlos' and 'Black Beauty'. These results suggest that pollination may not be a problem in present muscadine cultivars. Variation in yield among cultivars apparently relates to genetic differences in cluster number and berry weight.

223

Meiotic Behavior in an Amphidiploid Rose and Its Hybrid Progeny

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The amphidiploid rose 86-7 (*Rosa wichuraiana* x *R. rugosa rubra*) and its hybrids with the tetraploid breeding selection 82-1134 were analyzed for meiotic configuration frequencies and meiotic abnormalities. Genomic relationships in these hybrids were interpreted with the aid of a model of meiotic chromosome association in tetraploids. The optimized solutions to this model indicated a pattern intermediate between the "211" pattern, with one pair of closest genomes, and the "ring4" pattern, in which one of three possible pairing arrangements is strongly suppressed. The same configuration frequencies could also reflect a "4:0" pattern of equally similar genomes with more than two independent pairing and chiasma-forming domains per chromosome. The observed meiotic abnormalities included chromosome stickiness and asynchronous chromosome contraction within cells. Pollen stainability varied independently of meiotic irregularity or multivalent frequency.

224

Screening for Ploidy Variation in Collections of *Malus* (Apple) Species by Flow Cytometry

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Flow cytometry was used to determine the ploidy levels in three subsets of the apple germplasm collection held by the USDA-ARS Plant Genetic Resources Unit. C-values ranging from diploid to pentaploid DNA content have been reported in the genus *Malus*, but cytogenetic information is often not available for specific trees. Diploid, triploid, and tetraploid clones were found in the core collection, a diverse group of *Malus* species and hybrids. Ploidy level may vary within and between *Malus* species in the wild. The progeny of 38 *M. sieversii* trees sampled from a natural population near Targabatai, Kazakstan were screened with flow cytometry. All the tested progeny had diploid C-values. Gigas characters such as larger leaves and fruit are sometimes associated with elevated ploidy levels. Ten elite scions of large-fruited *M. sieversii* were evaluated. All 10 had C-values in the diploid range. While flow cytometry of nuclei liberated from leaf tissue gave the expected DNA content for cultivars with previously known ploidy levels, this technique could not distinguish a known 2-2-4-4 periclinal chimera from diploid individuals.

225

Pollination Mechanisms of *Ebenus cretica*

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Ebenus cretica L., is an endemic plant of Crete with potential as a cut flower or flowering potted plant. It is a herbaceous perennial evergreen subshrub that flowers from April to June. It forms numerous thick racemes with an average of 50 pink or purple flowers 10 to 12 mm long. A great variability in major morphological characteristics exists among the populations of *E. cretica* on the island; however,

color variants are very rare. Selection and breeding is a necessary prerequisite before the plant is marketable; therefore, research conducted at the TEI of Heraklion since 1994 has focused on artificial self- and cross-pollination of pink-flowered ebebus plants. It has been concluded that the zygomorphic flowers of *E. cretica* are pollinated by insects (bumblebees); the tripping mechanism occurs and seeds are formed by either cross- or self-pollination. For self-pollination, unripe flower racemes were enveloped in paper bags and shaken by hand or wind to release pollen; however, this method gave poor results. Best results were obtained by tripping the flowers while avoiding the introduction of foreign pollen. Self-incompatibility was not observed. Cross-pollination was achieved by emasculating flowers on the female parent, 2 to 4 days prior to the dehiscence of the anthers. The corolla is half-white and half-pink at this stage, turning to a uniform pink when the pollen is ripe. The stigma appears to be fully receptive at least 2 days before the dehiscence of the anthers. Each fertilized ovule gives one mature seed \approx 3 weeks after pollination. This research indicates that breeding techniques can be applied without difficulty to *E. cretica* in order to develop uniform plant material and new varieties/hybrids with desirable characteristic.

226

Stigmatic Pollen Grain Deposition by Honey Bees and Bumble Bees after Single Bee Visits to Pistillate Watermelon Flowers

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As a means to assess pollinator efficiency, the number of pollen grains deposited by honey bees (*Apis mellifera* L.) and bumble bees (*Bombus impatiens* Cresson) after single visits to pistillate watermelon [*Citrullus lanatus* (Thumb.) Matsum. & Nakai] flowers was compared. Pistillate flowers were enclosed in nylon bags prior to anthesis, and were then exposed to single visits by each bee species (RCBD: 10 flowers per bee species per replicate; 4 replicates). Pollen grains were removed from stigmata immediately after bee visitation by use of a glycerin jelly-gelatin mixture that was mounted onto microscope slides. Light microscopy was used to count the number of pollen grains per slide. Bumble bees deposited significantly more pollen grains than did honey bees ($P < 0.05$). After single bee visits to flowers, bumble bees deposited an average of 481 pollen grains, while honey bees deposited an average of 119 pollen grains. Although multiple bee visits are usually required to set watermelon fruit, this work demonstrates that bumble bees are more-efficient pollinators of watermelon at the single visit level than are honey bees.

227

Use of a Backcross Population to Target Genes Controlling Androgenesis in Potato

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Genes for anther culture response (ACR) need to be mapped to enable efficient transfer of the trait to unresponsive but agronomically desirable clones. The objective of this study was to find extremes for ACR in a segregating population to target genes controlling this trait using bulk segregant analysis. Populations resulting from backcrosses (BC) of a diploid interspecific clone [CP2: *Solanum chacoense* (*chc*: low ACR) and *S. phureja* (*phu*: high ACR)] to both parents were used to characterize two phases of androgenesis in a preliminary study: microspore embryogenesis and embryo regeneration. Among 24 plants from each BC, consistently high- and low-responding genotypes with regard to embryo production were identified. Low ACR clones in each BC produced from 0.0–0.1 embryos per anther (EPA), whereas high ACR clones in the *chc* and *phu* BC produced from 1.4–2.9 and 2.8–7.5 EPA, respectively. The frequency of embryos regenerating into plants ranged from 3% to 20% for the *chc* high EPA clones and 12% to 64% for the *phu* high EPA clones. Ploidy of regenerated plants was determined by flow cytometry. The frequency of monoploid regenerants among the high EPA clones ranged from 3.6% to 68%. Since these populations showed sufficient genetic variation for ACR, a series of statistically designed experiments were conducted to develop high and low ACR bulks. From four groups of phenotypically characterized PBC plants, a high ACR bulk ($\bar{x} = 4.9$ EPA; $n = 14$) and a low ACR bulk ($\bar{x} = 0.12$ EPA; $n = 9$) were constructed.

128 POSTER SESSION 3A (Abstr. 228–234) Pest Management—Woody Ornamentals/ Landscape/Turf

228

Effect of Preemergent Herbicides on Growth of Dwarf Nandina, Eleagnus, Asiatic Jasmine, Bradford Pear, and Arizona Ash

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The list of species that are known to tolerate the use of Factor[®] (prodiamine), a preemergent herbicide, in a containerized production system is limited. Plants of dwarf nandina (*Nandina domestica* 'Firepower'), eleagnus (*Eleagnus x eggingei*), and Asiatic jasmine (*Trachelospermum asiaticum*) growing in 3.8-L containers were obtained from a local nursery and treated with herbicide treatments to determine effects on growth. Plants were treated with one or two applications of Factor[®] 65WG at either 0, 1.4, 2.8, or 5.5 kg·ha⁻¹ (0.9, 1.8, or 3.6 kg·ha⁻¹ active ingredient, respectively). The first application was made on 10 Aug. 1995 and the second application was made on 19 Oct. 1995. Plants were grown under 30% Saran shade and watered and fertilized as needed. Plants of Arizona ash (*Fraxinus* sp.) and Bradford Pear (*Pyrus calleryana* 'Bradford') potted in 19-L containers were treated with herbicide treatments on 25 Oct. 1995 for fall weed control at a local nursery. Treatments included a single application of Factor[®] 65WG at either 0, 1.4, 1.8, or 2.8 kg·ha⁻¹ (0.9, 1.2, or 1.8 kg·ha⁻¹ active ingredient, respectively) with or without Gallery[®] (isoxaben) at 1.2 kg·ha⁻¹ (0.9 kg·ha⁻¹ active ingredient). There was no effect of the herbicide treatments on growth of eleagnus. Herbicide treatments did not affect shoot dry weight and did not have a deleterious effect on shoot length and root dry weight of Asiatic jasmine or affect trunk caliper growth of the two tree species. Factor[®] did affect the growth of dwarf nandina. Plant height and shoot and root dry weight were not affected. However, plant width was decreased by all Factor[®] treatments when compared to untreated plants.

229

Preemergent Weed Control in Container-grown Herbaceous Perennials

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During the 1997 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: Napropamide (Devrinol 10G), 0.72 and 1.44 kg a.i./ha; Oryzalin (Surflan 40AS), 0.36 and 0.72 kg a.i./ha; Oxadiazon (Ronstar 2G), 0.72 and 1.44 kg a.i./ha; Oxyfluorfen + Oryzalin (Rout 3G), 0.54 and 2.16 kg a.i./ha; Oxyfluorfen + Pendimethalin (Scott's OH II), 0.54 and 1.09 kg a.i./ha; and Trifluralin (Treflan 5G), 0.72 and 1.44 kg a.i./ha. Herbicides were applied to *Phalaris arundinacea* 'Picta', *Scabiosa caucasica*, *Sedum spectabile* 'Autumn Joy', *Pennisetum setaceum* 'Rubrum', and *Salvia argentea*. Phytotoxicity symptoms (visual defects and lower dry weights) were apparent with Napropamide on *Phalaris* (at both rates). All herbicides provided good weed control.

230

Toxicity, Uptake, and Distribution of Simazine in *Canna hybrida* 'King Humbert': Implications for Phytoremediation

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This research focuses on the potential use of *Canna hybrida* 'King Humbert', for removing simazine from contaminated water generated at golf courses and ornamental nurseries. Because of simazine's herbicidal activity, it is important for levels in solution not to exceed plant tolerance levels. Tolerance levels for *C. hybrida* were determined by dosing plants for 7 d with 0, 0.01, 0.03, 0.1, 0.3, 1.0, or 3.0 mg simazine/L nutrient media. Measurements of 7-d fresh mass production and photosynthetic efficiency (Fv/Fm) were taken. Simazine uptake and distribution within the plant was determined by dosing plants with 2.03 mCi ¹⁴C-simazine (0.243 mg/L) for 1, 3, 5, or 7 d. Plant tissues were analyzed by combustion and

liquid scintillation counting. Fresh mass production was reduced 66% and 78% for plants exposed to 1.0 and 3.0 mg/L, respectively. Likewise, photosynthetic efficiency was reduced to 66% and 40% of the controls at the same respective concentrations. Plant uptake of simazine accounted for 13%, 34%, 48%, and 65% of the original simazine in the dosing solution after 1-, 3-, 5-, and 7-d exposure, respectively. This simazine was distributed primarily between roots and leaves.

231

Suppression of Liverwort Growth in Containers Using Irrigation, Mulches, Fertilizers, and Herbicides

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Liverwort (*Marchantia* sp.) is often a serious weed in many nursery and greenhouse operations. Combinations of irrigation frequencies, surface mulches, surface fertilizers and herbicides were applied to the surface of the growing medium in 10-cm square pots planted with *Rhododendron* or *Picea*. Liverwort infestations were evaluated as the percentage of media surface covered. Mulches were placed at least 1/2-inch thick on the surface of the growing media. Five blocks of two pots per treatment were used in a completely randomized design. Oyster shell, hazelnut shell, and copper-treated geotextile mulches provided good suppression (less than 10% surface coverage) of liverwort for up to 6 weeks, while rockwool, peatmoss, coarse sand, perlite and pumice mulches required low-frequency irrigation to provide fair suppression (less than 40% surface coverage). Surface applications of oxadiazon (Ronstar), oryzalin (Surflan), iron oxide, copper sulfate, and manganese sulfate provided good suppression of liverwort for up to 4 weeks using low-frequency irrigation, but suppression was nearly eliminated if high-frequency irrigation was applied. Some combination applications of mulches and herbicides or fertilizers provided good suppression for 8 weeks (high-frequency irrigation) or 12 weeks (low-frequency irrigation). Liverwort suppression was fair when untreated geotextile mulches were used, but suppression was good (even under high-frequency irrigation) when copper-treated geotextile mulches were used.

232

Evaluation of Nurse Crops for Weed Control and Plant Establishment in Prairie Restoration

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Nurse crops are often recommended in prairie restoration planting. This work investigated several alternative nurse crops to determine their utility in prairie planting. Nurse crops were composed of increasing densities (900, 1800, or 2700 seeds/m²) of partridge pea, spring oats, spring barley, Canada wild rye, or equal mixtures of partridge pea and one of the grasses. The experimental design was a randomized complete-block set in two sites with three blocks per site and 48 treatments per block. Each 3 x 3-m plot contained 1 m² planted in Dec. 1995 or Mar. 1996 with an equal mix of seven prairie species. The nurse crops were sown over each nine square meter area in April 1996. Plots lacking nurse crops served as controls. Evaluated data consisted of weed pressure rankings and weed and prairie plant dry weight. Nurse crop treatments had a significant effect on weed pressure in both sites. Barley (1800 and 2700 seeds/m²) as well as partridge pea + barley (2700 seeds/m²) were most effective at reducing weed pressure. When weed and prairie plant biomass values were compared, a significant difference was observed for site quality and planting season. Prairie plant establishment was significantly greater in the poorly drained, less-fertile site and spring-sown plots in both sites had significantly higher prairie biomass values. Overall, after two seasons, there was no advantage in using nurse crops over the control. Among nurse crop treatments, oats were most effective in reducing weed competition and enhancing prairie plant growth.

233

Evaluation of Three Soil-applied Insecticides for Root Weevil Control in Container-grown Nursery Crops

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To determine efficacy of insecticides for adult root weevil control in container-grown plants, adult stages of black vine root weevil, *Otiorynchis sulcatus*, were established in two container-grown plant species, arborvitae (*Thuja occidentalis* 'Emerald') and rhododendron (*Rhododendron* 'Vulcan') in May 1997. Seven root

weevil adults were placed onto the soil surface of each 1-gal plant and covered with a damp paper towel. Insecticides were applied during daylight hours on 20 May 1997. Foliar treatments were applied using a manually pressurized backpack sprayer. Baits and granular treatments were applied by hand to the soil surface. On rhododendrons, treatments consisted of: 1) an untreated control; 2) Topcide (lambda-cyhalothrin, 1.2 oz/100 gal); 3) Topcide (lambda-cyhalothrin, 4.8 oz/100 gal); 4) Pinpoint 15G (acephate, 16.5 lb/a); 5) Pinpoint 15G (acephate, 33.0 lb/a); 6) Cryolite (Sodium aluminofluoride-based bait, 30 lb/a); and 7) Gowan 1885 (30 lb/a). There were five blocks per treatment, each containing five plants. At 1 and 7 days after treatment, root weevils were collected from each container and evaluated for moribundity and mortality. Treatments 1, 3, 5, and 6 were applied to arborvitae and evaluated 1, 3, and 8 days after treatment. Cryolite, Gowan 1885, and Pinpoint 15G (high rate) had the highest mortality (70% to 79%) compared to untreated (11% to 17%) or Topcide-treated plants. Pinpoint 15G and both sodium aluminofluoride bait treatments may provide an effective, viable option for adult root weevil control when pesticides cannot be applied in the evening or when reduction of risks from foliar cover sprays to non-target organisms is desirable.

234

Soybean Oil Used as an Alternative Pesticide on Nursery Stock

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Research was conducted to determine if soybean oil sprays may substitute for petroleum oil for control of insects on nursery crops. Dormant field-grown 'Globe' arborvitae shrubs infested with Fletcher scale were sprayed on 9 Mar. 1997 with 0%, 2%, 3%, or 4% soybean oil. One hundred scales per plant were evaluated on 4 Apr. 1997. Spraying 2% to 4% soybean oil on dormant arborvitae caused $\geq 97\%$ mortality of Fletcher scale compared to only 7% mortality on untreated plants. Of white pine, viburnum, 'Anthony Waterer' spirea, 'Green Beauty' boxwood, western red cedar, 'Blue Star' juniper, 'Blue Pacific' juniper, 'Japanese Garden' juniper, and arborvitae plants in trade gallon pots and 'Densiformus' yew and dwarf 'Alberta' spruce in trade quart pots were sprayed with 0% (water control), 1%, or 2% soybean oil (emulsified with Latron B-1956) or 2% SunSpray Ultra-Fine Spray oil on 26 Aug. 1997 for phytotoxicity evaluation. No phytotoxicity occurred on western cedar, spirea, boxwood, yew, arborvitae, or viburnum. Spraying SunSpray or soybean oil caused initial loss of blue color on blue junipers and white pine. Spraying 1 or 2% soybean oil or 2% SunSpray caused phytotoxicity to 'Blue Star' juniper. The 'Blue Pacific' juniper, 'Japanese Garden' juniper, and Alberta spruce were slightly damaged by 2% but not by 1% soybean oil.

128 POSTER SESSION 3B (Abstr. 235–242) Postharvest Physiology—Floriculture

235

Cytokinin and Auxin Sprays Affect the Incidence of Poinsettia Bract Necrosis

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In 1996, 'Supjibi red' poinsettias were sprayed at initial anthesis with the cytokinin benzyladenine (BA) (10 or 100 ppm), or with the cytokinin analogs CPPU or thidiazuron (1 or 10 ppm), or with Accel (10 or 100 ppm BA)—a 10:1 mixture of BA and gibberellin. A spray of thidiazuron at 1 or 10 ppm, Accel at 10 or 100 ppm, or BA at 100 ppm suppressed the incidence of necrosis relative to untreated plants. However, cytokinin treatments tended to induce the expansion of young bracts and fading of bract color. In a separate 1996 study, plants were sprayed with 100 ppm BA at 2-week intervals between visible bud and initial anthesis; and in 1997, 20 ppm of the auxin indole-3-butyric acid (IBA) was applied at similar intervals. The later in bract development that BA was applied, the lower the incidence of necrosis observed at 6 weeks after anthesis. In contrast to BA treatment effects, necrosis was highest with late IBA applications (when observed 3 weeks after anthesis). Late sprays of IBA induced bract epinasty. A 1:1 mixture

of BA plus IBA applied at initial anthesis at 25 or 50 ppm BA, suppressed bract necrosis without causing adverse side effects.

236

Early Onset of Poinsettia Bract Necrosis is Associated with Condensed Tannin Accumulation

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The early onset of bract necrosis in poinsettia (*Euphorbia pulcherrima* Willd. ex. Klotzch) is characterized by small dark-stained spots that precede the development of enlarged necrotic lesions. Electron micrographs of adaxial epidermal and subepidermal tissues with early symptoms of necrosis revealed large, electron dense deposits in cell vacuoles. These spherical bodies resembled condensed tannins observed in the epidermal tissues of peach and apple fruit. Chemical analysis of bract tissues showed higher condensed tannin concentrations in bract samples with 2 mm diameter lesions than in samples with lesions less than 0.5 mm (equivalent to catechin concentrations of 59 and 13 mg·g⁻¹ fresh mass, respectively). Tannin bodies were not observed in micrographs from parallel samples of healthy appearing bracts, and chemical analysis revealed only trace concentrations of condensed tannins in these tissues (0.2 mg·g⁻¹ fresh mass). The evidence suggests that condensed tannins accumulate in affected cells at the earliest observable stages of bract necrosis.

237

Mechanisms of the Prevention of Cold Storage-induced Post-harvest Leaf Chlorosis by Supplemental Light and Gibberellins in 'Stargazer' Hybrid Lilies

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Leaf chlorosis induced by short-term, postproduction cold storage is a common postharvest disorder in potted lilies. In 'Stargazer' hybrid lilies, 2 weeks of storage at 4 °C results in chlorosis in more than 30% of leaves by 6 days after transferring to 22 °C. Because we observed that foliar sprays of GA₄₊₇ or supplemental light during cold-storage could prevent this leaf chlorosis in *Lilium sp.* 'Stargazer' hybrid lilies, this study was conducted to investigate the mechanisms underlying these preventive effects. Hybrid lilies at "puffy bud" stage were stored for 2 weeks at 4 °C either in darkness (control), provided with 40 μmol·m⁻²·s⁻¹ light by cool-white fluorescent lamps, or sprayed with 100 mg·L⁻¹ GA₄₊₇ prior to storage. Leaves from lower half of the plant were sampled during cold storage and upto 6 days after transferring to 22 °C. Leaf chlorophyll, total nitrogen, and soluble protein concentrations decreased slightly during cold-storage in all treatments, but decreased rapidly after transferring to 22 °C only in control plants. Total soluble sugar concentration (TSS) in leaves decreased in control and GA₄₊₇-treated plants during cold storage, whereas TSS increased in plants provided with light. After transferring to 22 °C, TSS decreased in all treatments, but the decrease was more rapid in control plants. SDS-PAGE protein profiles revealed that degradation of larger polypeptides that occurred in control plants did not occur in GA₄₊₇-treated plants or plants provided with light. Catalase and superoxide dismutase activities in leaves decreased in control plants after transferring to 22 °C, whereas these activities were maintained in other treatments.

238

Effect of Flower Age on Ethylene Synthesis in Big Bend Bluebonnet, *Lupinus havardii*

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Endogenous ethylene production of an advance breeding line and an unimproved population of *L. havardii* was measured to determine at what age open flowers begin to synthesize ethylene. Twenty to 30 immature flower racemes from greenhouse-grown plants were randomly selected and tagged in each plant population. Every 24 h, the uppermost open flower was tagged on the selected racemes. On the 10th day, tagged racemes were harvested from each population group. Flowers were removed from the raceme, placed into 10-ml vials (six flowers/vial), and incubated at room temperature (25 ± 2 °C). Ethylene was analyzed using a gas chromatograph. Detectable ethylene levels were most prevalent in 3- to 4-day old

flowers. Mean ethylene rates were 1.7 nl/g per h and 1.1 nl/g per h for 4-day-old flowers of the advance breeding line and unimproved population, respectively. Senescing flowers (10 days old) of the advanced breeding line and unimproved population had ethylene rates of 7.9 and 6.7 nl/g per h, respectively.

239

Relationship Between Postharvest Longevity of Cut Flowering Stems and Intact Flowers of Greenhouse-grown *Antirrhinum majus* L.

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Considerable variation exists in *Antirrhinum majus* L. (snapdragon) for postharvest longevity of cut flowering stems. We have seen a range of 2 to 16 d postharvest life of snapdragon inbreds used in our experiments when evaluated in deionized water. A correlation between longevity of intact flowers and cut flowers has been reported for roses and tulips. In an effort to test this relationship on snapdragons, plants from a short-lived (5 days) and long-lived (16 days) inbred were grown in a greenhouse at the Univ. of Wisconsin, Madison, in Spring 1997. Plants began flowering in Apr.1997. The first three florets on each plant were tagged when fully open and the date of senescence recorded for each individual floret. Results showed a significant difference in longevity of intact florets. Mean floret longevity of the short- and long-lived lines was 13 and 25 days, respectively (LSD_{0.05} = 1.03 days). This is an indication that selection for postharvest longevity of snapdragons may be done based on intact flower longevity.

240

Vase Life of Cut Rose Flowers Harvested at Different Months and Treated with Poly(2-Hydroxypropyldimethylammonium Chloride)

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Flowering rose (cv. Rote Rose) stems, harvested at different months of the year, were placed in 250 ppm poly(2-hydroxypropyl)- dimethylammonium chloride)(PHPAC) solution or in water as the control at 4 °C for 24 h. They were then transferred to water and held at 20 °C for 6 or 7 days. Bent-neck of control roses was the greatest with those harvested in July, least with December or May harvest, and intermediate with October harvest, and occurred after day 2, 4, 4, and 3 at 20 °C, respectively. PHPAC reduced the occurrence and degree of bent-neck of all roses and had the greatest inhibitory effect on roses harvested in July. PHPAC accelerated flower opening of roses harvested in July and December. Rates of water uptake and transpiration decreased during the holding period, and PHPAC retarded the decrease after day 3-4 of all roses. Hydraulic conductance in the basal 3 cm segment of all rose stems decreased during holding and PHPAC retarded the decrease. Electrolyte leakage from the basal 3 cm of the stem was greater with the PHPAC-treated stems than that of the control of all roses. These results indicate that PHPAC suppressed bent-neck probably by reducing the rate of decrease in water uptake and transpiration, which related to the hydraulic conductance and electrolyte leakage in the basal 3 cm of the stems.

241

Vaselifevaluations of Autumn Sedum, Lobelia, Hardy Amaryl-lis, Oregano, and Blue Spirea

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Specialty cut flowers have come of age. In 1996, the value of domestic fresh cut roses, carnations and mums were \$195 million while the value of "other" flowers was \$251 million. As consumers acquire a taste for more new and different flowers, postharvest information is needed to determine what growers, vendors and consumers can expect for vaselife from these flowers and how the vaselife can be best extended. The vaselife of autumn sedum, lobelia, hardy amaryl-lis, oregano, and blue spirea was evaluated with and without pretreatments of STS and holding solutions of floral preservatives or water. Results were varied among the different species for the best handling procedures. Lobelia, blue spirea and autumn sedum flowers benefitted from the use of STS. The longest vaselife for oregano was 8.5 days, for blue spirea was 11.3 days, for lobelia was 14 days, for hardy amaryl-lis was 7 days and for autumn sedum was 32.5 days.

Effects of Ethylene Scrubber and Light on Yellowing of Geranium Transplants

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The yellowing of geranium transplants under simulated non-refrigerated transit conditions was investigated with \pm KMnO_4 -based ethylene scrubber or supplemental light. The transplants were stored in the dark at 20 °C in glass jars or cartons, some of which were treated with \pm ethylene scrubber (8 g) and/or \pm light. Transplants (8) were removed daily for measurement of leaf yellowing intensity (= percentage of the sum of the products of yellowing rate and leaf number within the rate over the potential maximal sum, where rate 0 equals no yellowing; 1, discrete margin yellowing; 3, yellowing along margin; 4, uniform yellowing). Yellowing was evident after 1 day storage (3 days postharvest). The yellowing of 'Pinto Red' geranium transplants stored in cartons progressed similarly \pm ethylene scrubber (\approx 99% yellowing intensity on day 5). In jars, the scrubber delayed the yellowing of 'Pinto Red' from 83% to 75% by the end of the 5-day test period. In a separate test of 'Pinto Salmon' in jars, yellowing was delayed from 68% without scrubber to 30% with scrubber. Weak incandescent light plus scrubber substantially reduced yellowing in 'Pinto Pink' (43%) compared with dark, - scrubber (96%) after 6 day storage. Under fluorescent light, yellowing in 'Pinto Pink' was \approx 20%. The results showed that the absence of light was the key stress factor causing yellowing in geranium transplants. Yellowing retardation by ethylene scrubber was observed only in a closed system and the effect was variety dependent.

128 POSTER SESSION 3C (Abstr. 243–248) Crop Physiology: Genetics/Cultivars/Selection—Cross-commodity

243

Genotypic Influences on Fatty Acid Profiles and Germinability of Pecan Pollen

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Pollen of pecan [*Carya illinoensis* (Wangenh.) K. Koch] from five protandrous and five protogynous genotypes was analyzed for germinability and fatty acid profile. Fatty acid profiles as a function of genotype were distinctive in all selections, but only three of the genotypes had fatty acid profiles that were easily distinguishable from others by canonical discriminant analysis. Specific fatty acid percentages influenced germination in some genotypes. Total saturated and unsaturated fatty acids influenced pollen germination to a greater degree than individual fatty acids. The effects of fatty acids on pollen germination of protandrous genotypes were opposite those on 'Stuart', the only protogynous genotype to be influenced by fatty acid percentages.

244

Evaluation of *Prunus cerasus* Germplasm for Cold Resistance

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Knowledge of the level of cold stress resistance and how this resistance is inherited in sour cherry is essential to cultivar development and future germplasm collection. Twig and flower bud samples of two sweet cherries (*Prunus avium* L.), 12 sour cherries (*Prunus cerasus* L.), and one ground (*Prunus fruticosa* Pall.) were collected once a month from Aug. 1990 to Mar. 1991, preconditioned, and subjected to freeze tests and differential thermal analysis. LTEs were detected in all stems of *P. cerasus* investigated and were strongly correlated to xylem ITs in December to March. LTEs were strongly correlated to phloem-cambium ITs in November. Xylem ITs were the selected method for evaluating sour cherry cold resistance in December to March. Phloem-cambium ITs were the selected method for November. The degree of hardiness of the phloem-cambium in late fall and early spring is a factor determining *P. cerasus* germplasm geographic

distribution and commercial production. The principal component (PC) analyses, of the phloem-cambium and cortical tissues, depict gradations between minimum survival temperatures of the two presumed progenitor species of sour cherry, sweet cherry and ground cherry suggesting that cold is a major selective force, contributing to sour cherry population variation.

245

Induction of Chlorophyll-deficient Phenotypes in *Tillandsia fasciculata* Swartz Var. *fasciculata* by Physical and Chemical Mutagens

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Seeds of *Tillandsia fasciculata* var. *fasciculata* were treated with gamma radiation, gamma and thermal neutron radiations, or ethyl methanesulfonate (EMS) and grown in vitro. Observed chlorophyll deficient phenotypes included yellowish-green, yellow, variegated and albino. The highest combined percentages of chlorophyll deficient phenotypes was 8.7% for the gamma radiation treatment (2.7 krad), 4.6% for the gamma and thermal neutron radiations treatments (combined dose of 2.7 krad at a gamma to thermal neutron ratio of 7.4:1.0), and 10.8% for the EMS treatment (0.4% EMS x 5 h). Some yellowish-green and yellow seedlings multiplied in half strength MS medium with 0.3 or 0.5 μM BA and IBA and the newly formed shoots retained their respective mutant phenotypes. However, the variegated seedlings were sectoral or mericlinal chimeras and when they multiplied, the newly formed shoots were not variegated. The chlorophyll a/chlorophyll b ratio of the wild type seedling was 1.1 whereas that of the yellowish-green and the yellow seedlings was 2.0. Electron micrographs showed that compared to the wild type chloroplasts, the chloroplasts of the yellowish-green and yellow seedlings had fewer grana and fewer thylakoids within each granum.

246

Changes of Lipid Components During Dormancy in Blackberry Cultivars

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Changes in phospholipids, galactolipids, and fatty acid were determined in two cultivars of blackberries, 'Triple Crown' and 'Hull Thornless', during dormancy and budbreak. Under field conditions, 'Triple Crown' required lower chilling units (CUs) than 'Hull Thornless' to overcome dormancy. 'Triple Crown' and 'Hull Thornless' achieved full budbreak after receiving 600 and 1000 CUs, respectively. Under cold-temperature treatments, 'Triple Crown' needed 400 CUs, while 'Hull Thornless' needed 600 CUs at 4 °C to obtain 100% budbreak. The shoots kept at intermittent 6/24 °C (6 °C for 16 h, and 24 °C for 8 h) did not reach full budbreak even after receiving 1000 CUs. An increase in phospholipids and glycolipids was observed during the termination of dormancy. The increase in phospholipids occurred earlier than the increase in glycolipids. The percentage of 18:2 fatty acid decreased while 18:3 increased and there was approximately a five-fold increase in the 18:3/18:2 ratio observed at the time of budbreak. The increase in the 18:3/18:2 ratio could serve as an indicator of dormancy termination and growth resumption in blackberry.

247

Biomass Partitioning and Yield of Three Asparagus Hybrids

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This study was conducted to learn when an asparagus plant partitions its biomass into leaves, stems, buds, and rhizomes, and roots and to determine when after harvest the crown of the plant is rejuvenated to the point that harvest can begin again. The plants used in this study were generated by sowing seed on Jan. 1995, transplanting seedlings into 1.8-L containers (5 sand : 4 soil : 1 peat) in Mar. 1995 and on Mar. 1996, placing the crowns into 9.5-L containers. During Fall 1996, the number of shoots per plant were recorded and this data was used to group plants into six classes. The study was started on 8 Apr. 1997 by first removing six plants/cultivar (one from each class) and biomass partitioning each crown into buds and rhizomes, and roots. The remaining plants were harvested eight times and after the final harvest on 20 Apr. another set of plants (six/cultivar) were partitioned. Starting on 3 June, a set of plants were partitioned every 2 weeks until 21 Oct., when growth stopped in the fall. Atlas and UC157 F₁ produced the most spears and had the highest yield and they also had the highest total dry

weight, leaf dry weight, and stem dry weight. There were no cultivar differences in rhizome and root dry weight. However, 'Jersey Giant' and 'Atlas' had the highest rhizome and root weight ratio. The highest bud dry weights occurred on 20 May, 23 Sept., 26 Aug., and 21 Oct. and the highest rhizome and root dry weights were on 21 Oct., 12 Aug., 26 Aug., and 23 Sept. The bud dry weight recorded on 12 Aug. was equal to the bud dry weight recorded on 8 Apr. Also on 12 Aug., leaf dry weight and rhizome and root dry weight were higher than almost all the other dates. In addition, above-ground shoot counts and bud dry weights were higher on 26 Aug. than on 12 Aug. All this data indicates that in this study sometime after 12 Aug. and before 26 Aug., the asparagus crown was completely rejuvenated and ready for another cycle of harvesting.

248

Identification of cDNAs from *Cornus sericea* that Encode a Family of Dehydrin-like Proteins

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Three cDNAs, which apparently encode a family of dehydrin-like proteins, were isolated from cold-acclimating wood tissues of *Cornus sericea*. The nucleic acid sequences of these cDNAs are similar to each other (minimum 58% identical). Two of the cDNAs are predicted to encode proteins of 44 and 48.6 kDa. The third cDNA did not contain the complete open reading frame, but apparently encodes a much larger protein. The predicted amino acid sequences from all three cDNAs share homology with members of the dehydrin family of proteins. This family of proteins is characterized by the presence of a highly conserved lysine-rich consensus sequence (EKKGIMDKIKEKLP) known as the K-segment, a tract of serine residues, and in most instances, an N-terminal consensus sequence (DEYGNP) designated as the Y-segment. The cDNAs isolated from *C. sericea* encode putative proteins with these common motifs. Each has a tract of serine residues, and either one or two lysine-rich segments. However, a unique feature of the cDNAs from *C. sericea* is that they encode putative proteins having 21, 24, and 27 repeated sequences similar to the Y-segment, whereas previously identified members of the dehydrin family exhibit only one to three such repeats. The significance of this difference is not known. Dehydrins have been implicated in desiccation tolerance, and typically accumulate in response to dehydrating conditions, such as occur during drought, salt-stress, low temperatures, and during the late stages of embryogenesis. In *C. sericea*, expression of these transcripts changed seasonally. Northern blot analysis detected high levels of transcript in October and January, and no detectable message in June.

128 POSTER SESSION 3D (Abstr. 249–252) Hydroponics & Seed Establishment— Vegetable Crops

249

Improving Productivity of Hydroponically Grown Cowpea using Intracanopy Lighting

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High planting densities of planophile- or horizontal-leaved crops creates a problem called mutual shading, whereby leaves in the upper portions of plant canopies shade lower leaves. This can reduce overall crop productivity. In an effort to negate this problem in growth chambers, light intensity typically is increased from large overhead lamp banks. This is both expensive and inefficient. We have investigated the use of small, low-wattage lamps arranged in three-dimensional space allowing cowpea (*Vigna unguiculata* L. Walp 'IT87D-941-1') to grow up and around the lamps in a technique called "intracanopy lighting." This illuminates the interior portions of plant stands and keeps the majority of the canopy productive. Results obtained from this novel alternative to high intensity light from overhead lamps showed productivity rates as good as traditional production methods while using less than 25% of the light energy. We have continued to investigate variables associated with improved productivity in high density plantings including: lamp orientation, total light energy, photoperiod, and CO₂ concentration. Intracanopy lighting has the potential to significantly reduce the amount of energy required to produce a crop in a controlled environment.

488

250

Performance of Three Species of Salad-type Plants Grown under Narrow-spectrum Light-emitting Diodes (LEDs) in a Controlled Environment

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Light-emitting diodes (LEDs) are a promising light source for growing crop plants in spaceflight systems because of their superior safety, durability, small mass and volume, wavelength specificity, and long life. To address the usefulness of LEDs as a plant lighting source, radish (*Raphanus sativus* L. cv. Cherielette), lettuce (*Lactuca sativa* L. cv. Waldmann's Green), and spinach (*Spinacea oleracea* L. cv. Nordic IV) were grown using nutrient film technique hydroponics under cool-white fluorescent (CWF) lamps, red LEDs (peak emission 660 nm), and red LEDs + 30 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ supplemental blue fluorescent (BF) light (400–500 nm). Each lighting treatment was maintained in a separate controlled-environment chamber with total photosynthetic photon flux (PPF) maintained near 300 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ and a photoperiod of 18-h light/06-h dark. Results showed significant reductions in total dry mass (TDM) accumulation for radish plants grown under red LEDs + 30 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ BF or red LEDs only as compared to CWF-grown plants. Although TDM tended to decrease with decreasing BF for lettuce, treatment differences were not significant. TDM for spinach plants was significantly less under red LEDs compared to CWF or red LEDs + 30 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ BF. Interestingly, single-leaf photosynthesis and leaf conductance were not significantly different for any treatment, regardless of species. The data suggest a species-specific response for the amount of blue necessary for normal plant growth.

251

Moisture Soil Level Determination in Husk Tomato (*Physalis ixocarpa* Brot.) Crop in Western Mexico

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When moisture conditions in soil are suitable, the husk tomato has good vegetative growth and high yield. The objective of this work was determine the minimum available moisture level to obtain the highest yield, and establish an irrigation calendar. Treatments evaluated were: 15%, 30%, 45%, and 60% of moisture reduction in soil, according to the gravimetric method, in a randomized complete-block design with four replications. The variance analysis and Duncan test were carried out at a 0.05 level of probability for following variables studied: Fresh fruit yield (kg/ha), plant height, root length, and fruit diameter. The results show that a 30% reduction moisture level was remarkable with a 28,610.67-kg/ha yield of fresh fruit. In relation to agronomics characteristics, the results show that, for plant height, root length, and fruit diameter were remarkable with the 15% and 60% reduction moisture, respectively. This was due to the greater interval of irrigation and tendency of root system to search for moisture. The greater vegetative growth and yield is with a moisture level of 65% to 80% present in soil, indicating that the husk tomato tolerates this 30% of reduction moisture, with higher values producing more stress in plants and modifying the vegetative growth and production.

252

Yard Trimmings–Biosolids Co-compost can Substitute for Sphagnum Peatmoss in Tomato (*Lycopersicon esculentum* Mill.) Transplant Media

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Large volumes of a compost made by mixing and co-composting yard trimmings (YT) and biosolids (BS) feedstocks have recently become available to the Florida vegetable industry. Compost used as vegetable transplant medium may be less expensive than traditional Sphagnum peatmoss, which is a non-renewable resource. 'Agriset 761' tomato seed were planted in five combinations of compost, peat, and vermiculite media: 0:70:30 (control), 18:52:30, 35:35:30, 52:18:30, and 70:0:30 by weight, respectively. The presence of compost in the media increased leaf area, shoot dry weight, and number of leaves 21 days after treatment (DAT), and leaf area, shoot dry weight, root dry weight 28 DAT compared with the control. There were no differences in root dry weight 21 DAT and number of leaves 28 DAT between treatments containing compost and the control. Plants in the compost treatments had greater final leaf area, shoot dry weight, root dry weight, and stem

diameter but less chlorophyll content compared with the control. There was no effect of compost rate on any of the response variables measured. Neither final leaf number nor stem length were affected by media composition. The results suggest that YT/BS co-compost can be used as an alternative to peat media for tomato transplant production, and that the rate of use is not critical.

128 POSTER SESSION 3E (Abstr. 253–259) Postharvest Physiology—Solanaceous Crops

253

Characterization of Glutamate-1-Semialdehyde Aminotransferase and Its Activity Throughout Tomato Fruit Development and Ripening

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Glutamate-1-semialdehyde aminotransferase (GSAT) is a key enzyme in the regulation of chlorophyll biosynthesis and a plausible site to regulate chlorophyll loss during fruit development via a decrease in its activity. The primary objective of this research was to characterize GSAT from tomato fruit by varying substrate concentration and pH and to measure GSAT in various organs of the tomato plant. A secondary objective was to measure GSAT activity and chlorophyll concentration at 5-day intervals from 10 d to 60 d postanthesis during tomato fruit development and ripening. An optimum pH of 7.0 was found, and a maximum velocity (V_{max}) of $2.3 \text{ nmol}\cdot\text{g}^{-1}$ of tissue and a K_m of $119 \text{ mmol}\cdot\text{L}^{-1}$ were calculated for GSAT. Activity among organs was greatest at $3.84 \text{ nmol}\cdot\text{g}^{-1}$ tissue in leaves of 4-week-old seedlings, $1.67 \text{ nmol}\cdot\text{g}^{-1}$ tissue in fruits 15 days postanthesis, and below $0.70 \text{ nmol}\cdot\text{g}^{-1}$ tissue in roots, stems, and overripe fruits (65 d postanthesis). During fruit development, GSAT activity was greatest at 10 d postanthesis and declined to day 25. Activity increased from day 25 to a peak at day 40 and then decreased again during ripening to 60 d postanthesis. Total chlorophyll and chlorophyll a concentrations in tomato fruit declined throughout development and ripening with the greatest decrease between 10 d and 25 d postanthesis. Thus, GSAT activity may contribute to the control of chlorophyll concentration in tomato fruit from 10 to 25 d postanthesis when chlorophyll loss mirrors the decline in GSAT activity.

254

Effect of Potassium Permanganate-based Scrubber on Micro-environment Ethylene Levels and Tomato Ripening

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The effectiveness of a potassium permanganate-based ethylene scrubber on removing simulated package atmospheric ethylene and its effect on ripening of tomato fruit were investigated. In a closed system (glass jars) (fresh wt./container vol. ratio = 0.29) at 12°C , ethylene released by tomatoes at the turning stage accumulated to 26 ml/L within 2 days [$(\text{CO}_2) = 9\%$] and 33 ml/L within 6 days [$(\text{CO}_2) = 14\%$]. Ethylene, however, was undetectable in head space of jars containing 8-g scrubber materials. In the presence of ethylene scrubber, respiration rates were reduced as indicated by the delay in CO_2 accumulation. After holding at 20°C for 6 days following a 16-day, 12°C storage, deformation under 9.8 N was less in fruit with scrubber (2.9 mm) than fruit without scrubber (3.6 mm). Under a flow-through system, however, fruit surface color and deformation were similar with and without scrubber. The results indicate that an ethylene scrubber can slightly retard ripening of unripened tomato fruit stored in closed environment conditions.

255

Electronic Nose: A Non-destructive Technology to Screen Tomato Fruit with Internal Bruising

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Tomato (*Lycopersicon esculentum* Mill) fruit, cv. Solar Set, were harvested at the mature-green stage and gassed with $100 \text{ mg}\cdot\text{kg}^{-1}$ of ethylene at 20°C . At the breaker stage, fruit were held by vacuum to avoid fruit rotation and dropped

from a 40 cm height on a metallic, solid, smooth surface. Following impact, fruit were stored at 20°C and 85% to 95% relative humidity until table-ripe stage. Bruised and unbruised fruit were then placed individually inside the electronic nose-sampling vessel and the 12 conducting polymer sensors were lowered into the vessel and exposed to the volatile given off by the fruit. Data were analyzed employing multivariate discriminant analysis (MVDA), which maximizes the variance between treatments. The degree of dissimilarity was defined using the Mahalanobis distance and posterior probabilities were calculated to accurate re-classification of cases. The differences found between bruised and unbruised fruit were highly significant ($P < 0.0041$). The Mahalanobis distance between groupings (28.19 units) was a dramatic indicative of the differences between the two treatments. The re-classification of bruised and unbruised fruit using a single linear discriminant function was highly accurate, being 1.0 for both bruised and unbruised fruit. The electronic nose proved to be a useful tool to nondestructively identify and classify tomato fruit exposed to harmful postharvest practices such as mechanical injuries. However, there are still some factors that must be investigated, including system stability and the development of specific sensors for specific commodities.

256

Influence of the β -subunit Protein on Pericarp Softening, Cell Wall Hydrolysis, and Ultrastructural Changes in Ripening Tomato Fruit

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The function of the β -subunit protein in the cell wall metabolism of ripening tomato fruit is unknown. We examined pericarp softening, and polygalacturonase isozyme 2-mediated cell wall and pericarp tissue hydrolysis using tomato fruit ('Ailsa Craig') expressing an antisense gene for the cell wall-subunit protein. Softening of pericarp tissue was accelerated in the β -subunit-deficient compared with wild-type fruits, decreasing from an average of 22 N at the mature-green stage (both lines) to 9 N (12.7, wild) at the turning-pink stage to 2.5 N (5.1, wild) at the ripe stage. Pectin solubilization was enhanced significantly in the antisense line compared with the wild type, but differences in depolymerization patterns were minimal. Scanning electron microscopy of pericarp tissue revealed no differences in the tomato lines at the mature-green stage. During ripening, the pericarp tissue of the antisense fruit exhibited a more extensive loss in cell wall rigidity evident from the collapsed appearance of cell walls. Application of purified PG2 to the cut surface of mature-green pericarp tissue induced ultrastructural changes paralleling those observed during ripening of the two fruit lines. Refracture of PG2-treated, mature-green pericarp tissue showed that enzyme activity was confined to the tissue surface in wild type fruit, but penetrated at least several cell layers in the antisense line. Although some workers have suggested that the role of the β -subunit is not related to PG1(PG2+subunit) formation, we conclude that the protein influences pericarp tissue softening and cell wall hydrolysis by limiting the mobility and catalytic capacity of PG2.

257

Chilling Injury Determination in Tomato Fruit using Electrolyte Leakage and Chlorophyll Fluorescence Techniques

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The present work was carried out to evaluate chilling injury in tomato fruit, cv. Santa Clara and EF-50, employing chlorophyll fluorescence and electrolyte leakage techniques. Fruit were harvested at the mature-green stage and stored at 5 and 10°C for 14 days. Chlorophyll fluorescence was analyzed every 2 days, whereas electrolyte leakage was measured every 7 days. It was observed that cv. Santa Clara stored at 10°C had no statistical alteration in Fv/Fm ratio and did not show a significant increase in electrolyte leakage. These results indicate that tomato fruit, cv. Santa Clara, were not injured during the analyzed period. On the other hand, fruit stored at 5°C showed a significant decrease in Fv/Fm ratio after 6 days whereas electrolyte leakage was significantly higher at the 14th day of storage. For cv. EF-50, it was observed that fruit stored at 10°C had a significant decrease in the Fv/Fm ratio after 10 days, although there was no statistical difference for electrolyte leakage. For fruit stored at 5°C , it was verified that Fv/Fm ratio significantly decreased after 2 days and electrolyte leakage was significantly higher after 7 days of storage. Based on the results presented, it is suggested that tomato fruit, cv. Santa Clara, is potentially more resistant to chilling injury than cv. EF-50 and chlorophyll fluorescence proved to be a useful tool to study

physiological stresses such as chilling injury.

258

Effect of Harvest Maturity and Ethylene Gassing on Tomato Flavor Volatile Concentrations

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Tomato fruit (*Lycopersicon esculentum* Mill.) cvs. Solar Set and Olympic were harvested at three maturity stages: green (stage 1, USDA color classification) gassed with 100 ppm ethylene, green not gassed, turning (stage 4), and red-ripe (stage 6). After ripening at 21 °C, the fruit were homogenized with CaCl₂ and analyzed for important flavor volatile compounds. For 'Solar Set', acetone, ethanol, 1-penten-3-one, hexanal, and *trans*-2-heptenal were significantly higher in red-harvested fruit, while 2+3-methylbutanol, and *trans*-2-hexenal were higher in green-harvested fruit. *trans*-2-Hexenal was at higher levels in green-harvested fruit not gassed compared to those that were gassed for 'Solar Set'. 'Olympic' fruit followed similar trends for harvest maturity and gassing, but there were fewer significant differences in volatile levels. Using a multivariate discriminant pattern recognition procedure, red fruit were separated from turning and green-harvested fruit, while green-gassed separated from non-gassed based on the aroma volatile profile within each cultivar.

259

Characterization of Ethylene and CO₂ Production, Ethylene Binding Sites, and 1-Aminocyclopropane-1-carboxylic Acid in Different Types of Peppers

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Peppers are very popular as a vegetable, ornamental, and spice. They have been classified as non-climacteric fruits, but some types of hot peppers have been reported as climacteric. Comparisons of ethylene and CO₂ production, binding sites and 1-aminocyclopropane-1-carboxylic acid (ACC) content between pepper types were made. Experiments in both field and greenhouse conditions were conducted. Fruits were harvested at different stages of maturity. They were placed in jars at 27 °C and ethylene and respiration rate were determined by gas chromatography. All the variables studied showed differences among pepper types. These variations were more evident in wild types than in cultivated types. Variability in the results was also higher in wild types. When the same type of pepper grown in the greenhouse and in the field were compared, significant differences were evident. Differences in maturity patterns were observed among types. These results suggest that ripening patterns, ethylene production, respiration rates and ethylene binding sites are highly dependent on the type of pepper. Differences are also dependent upon the stage of maturity and should be taken in account when harvesting and storing pepper fruits.

128 POSTER SESSION 3F (Abstr. 260–267) Crop Physiology: Water Status/Stress— Cross-commodity

260

The Relationship Among Storage Condition and Seed Moisture Content Revisited

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Seed moisture content (MC) changes depending upon relative humidity (RH) and temperature (T). This relationship was revealed by studying the interaction of RH and T at equilibrium. Maize, cucumber, onion, lettuce, watermelon, and pea seeds were equilibrated over various saturated salt solutions (1% to 93% RH) at temperatures from 5 to 50 °C. Five-hundred-eleven subset models were selected from a complete third-order model $MC = 0 + 1 * RH + 2 * T + 3 * RH^2 + 4 * T^2 + 5 * RH * T + 6 * RH^3 + 7 * T^3 + 8 * RH * T^2 + 9 * RH^2 * T$ using Mallows' minimum Cp as the selection criterion. All six best subset models were found to have the same functional

form, $MC = 0 + 1 * RH + 2 * T + 3 * RH^2 + 5 * RH * T + 6 * RH^3 + 9 * RH^2 * T$. Coefficients had essentially the same respective values among species, except for the onion and pea models ($C_p \leq 0.05$). All models indicated that seed MC increased as RH increased and decreased as temperature increased. A previous paper (Vertucci and Roos, 1990) indicated that optimum RH for orthodox seed storage is between 19% and 27%. Using these models, the range for the optimum moisture content for storage of most orthodox seeds can be quickly calculated for any given storage temperature.

261

Measurement and Calculation of Total Plant Water Use of Citrus

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This preliminary study serves to parameterize a modified Penman-Monteith equation for young citrus trees. Two-year-old citrus trees ('Hamlin' grafted on Carrizo citrange) were planted individually into 1500-L (1.5-m-diameter) plastic pots in late Oct. 1997. Pots were placed upon industrial scales with a maximum weight capacity of 2270 ± 0.05 kg. Continuous weight measurements were made every minute and average half-hourly values recorded. An automated weather station was located within 10 m of the pots and half hourly values of temperature, humidity, wind speed, rainfall, and net radiation were recorded. Meteorological data, coupled with diurnal measurements of stomatal conductance taken periodically throughout the experimental period and leaf area for each tree allow calculation of total plant water use using a modified Penman-Monteith equation. These calculation may be cross-checked using weight change measurements. Such model parameterization for citrus will aid irrigation management of citrus in the field as it provides a link between the physiological and meteorological aspects which drive plant water use.

262

Drought Behavior of Nonbearing Clingstone Peaches on GF 677 Rootstock Cultivated under Field Conditions

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Water relations, chlorophyll and proline content, and vegetative growth were obtained from three clingstone peach genotypes (S135) grafted on peach x almond hybrid (GF 677) rootstock (S135/GF 677) and seedling trees from S135 (SPTS135). The experiment was carried out under field conditions during the dry season (April–June) to evaluate the influence of the GF 677 rootstock on scion. In 1997. Leaf water and osmotic potentials tended to be lower in S135/GF 677 than SPTS135 trees and irrigated seedlings peach trees (control). Although S135/GF 677 trees developed the lowest osmotic potential, the turgency was similar to SPTS135 trees. Relative water content and transpiration rate were the lowest in S135/GF 677 trees; SPTS135 trees were intermediate between S135/GF 677 and control trees. Chlorophyll and proline levels were increased in S135/GF 677 and SPTS135 trees compared with the control. Shoot growth was significantly delayed in S135/GF 677 trees compared with SPTS135 and control trees. Even though some scion physiological variables were modified by the GF 677, rootstock, the effect was not big enough to confer significant drought resistance to the scion.

263

Depletion Evaluation of the Available Moisture in 'Mission' Olives

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The area of olives in the region of Caborca has been increasing in the past years to 4500 ha. Olives in other regions do not need the application of water, but here at Caborca evaporation is greater than rainfall. Because of this, an experiment was conducted in 1997 to determine the optimum water requirements for olives (table olives) in a sandy loam soil. The results indicated that the greatest yield (22.68 kg/tree) was with 40% depletion of the available moisture (AM) in the soil, and the lowest yield (7.46 kg/tree) was with 100% depletion of the available moisture in the soil. The total water applied with the 40% depletion of the AM was of 239.81 cm (2.4 m).

Determining the Performance of Five Ornamental Grasses under Reduced Moisture Conditions

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An experiment was conducted to evaluate the performance of five ornamental grass species under reduced moisture. This experiment was conducted in the greenhouse with three water treatments for each species: 1) Well-watered plants were irrigated daily throughout the experiment, 2) acclimated-plants were exposed to four drought cycles prior to a final drought period in which measurements were taken, and 3) non-acclimated plants received daily irrigation until undergoing a drought cycle in which measurements were taken. A drought cycle was defined as the time from irrigation until Time Domain Reflectometry (TDR) measured 0 (zero). Preliminary observations determined the plants to be under severe stress, but capable of recovering at TDR measurements of 0. All plants were established from tillers of a single parent for each species. Two plants of each species for the three treatments were established in five blocks. Leaf water potential, osmotic potential, transpiration, stomatal resistance, and relative water content were measured during the drought cycle. At the end of the experiment the leaf area and root and shoot dry weights were determined, root to shoot ratio and leaf area ratio were calculated, and the plants were analyzed for macronutrient and micronutrient contents.

Water State and Release from Dormancy in Blueberry Flower Buds

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Three blueberry (*Vaccinium* section *Cyanococcus*) genotypes, that have different chilling requirements and levels of cold hardiness, were studied. Dormancy was evaluated and water status determined, using Nuclear Magnetic Resonance, throughout the accumulation of chilling that leads to release from dormancy. Among the two highbush cultivars studied, 'Bluecrop' (*Vaccinium corymbosum*) was the most dormant and 'Gulfcoast' (*Vaccinium corymbosum* x *Vaccinium darrowii*) was the least dormant. The rabbiteye cultivar Tifblue (*Vaccinium ashel*) had an intermediate dormancy. From estimates of chilling requirements (CRs), it appeared that the cultivar with the deepest dormancy had the highest CR. The NMR results showed that 'Bluecrop' buds had the lowest relaxation times (T₂), indicating that water was relatively more bound in 'Bluecrop' buds than in the buds of the two other cultivars. Whatever the cultivar, no significant variation of T₂s and water content of the buds was noted throughout the accumulation of chilling, even after CRs were satisfied. On the other hand, a transition from bound to freer water occurred if the plants were placed under forcing conditions (24 °C, long day) after they had received enough chilling to satisfy their CRs. The results suggested that the level of bound water was more associated with the level of cold hardiness rather than with the level of dormancy.

Soil-Root Interface Water Potential in Sweet Corn Affected by Organic Fertilizations and Effective Microbe Applications

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We examined effects of organic fertilizations and effective microbes (EM, mainly *Lactobacillus*, *Rhodopseudomonas*, *Streptomyces*, and *Aspergillus*) applications on soil-root interface water potential Ψ_{s-r} of 'Honey-Bantam' sweet corn. The contributions to Ψ_{s-r} from root amount and root activity were analyzed using the Ohm's law. Plants were grown in 1/5000 a Wagner's pots filled with Andosol and six treatments were made as follows: 1) organic materials fermented anaerobically with EM added; 2) anaerobic organic materials; 3) organic materials fermented aerobically with EM added; 4) aerobic organic materials; 5) chemical fertilizers with EM applied, and 6) chemical fertilizers. One month after sowing, as soil water decreased, Ψ_{s-r} was maintained higher in organic fertilized plants than chemical fertilized ones and also higher in plants with EM applications than those without EM. The relatively high Ψ_{s-r} was contributed by both their large root

amount and high root activity. As a consequence, photosynthesis under soil water deficit conditions were also maintained relatively high in these plants. Maintenance of a high Ψ_{s-r} favored plants to resist against water deficits. Moreover, the Ψ_{s-r} analysis is a practicable additional means to examine the soil-plant water status under undisturbed conditions.

128 POSTER SESSION 3G (Abstr. 268–273) Crop Production—Cross-commodity

Protective Border Plantings for Ag/Urban Interfaces

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Protective border barriers were established at three sites in commercial floriculture, and strawberry fields in San Diego County, Calif. These border plantings were used to provide a physical barrier between agricultural fields and adjacent urban development, and to evaluate the effects of border plantings on insect populations, spray drift, and crop/barrier interactions. Border plantings consisted of native plants with overlapping flowering periods to provide nectar and pollen to beneficial insects throughout the year. Yellow sticky traps were used to monitor insect populations, and water sensitive paper was used to evaluate the reduction of spray drift by the border plantings. Results indicate that protective border plantings: 1) can be used to form attractive physical barriers that reduce visual pollution and spray drift; 2) provide habitat for pests as well as beneficial insects; 3) support beneficial insects that may help reduce the population peaks of pest insects during spring and summer months; and 4) have little effect on adjacent crop fields.

Foliar Application of Ethephon Decreases Apical Dominance in 'Orchid' Petunia (*Petunia x hybrida* Vilm.-Andr.)

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Ethephon was applied as a foliar spray to 36-day-old petunia seedlings to determine its effectiveness at reducing apical dominance by increasing lateral shoot development. Ethephon application at rates of 125, 250 and 500 mg·L⁻¹ to whole shoots of *Petunia x hybrida* 'Orchid' decreased apical dominance compared to the control. The average length of a lateral shoot increased 56% as ethephon application rates increased from 0 to 500 mg·L⁻¹. In Expt. I, ethephon-treated plants had a greater number of laterals than control plants. The number of nodes produced before the first flower bud was initiated increased from 15 to 21 as rates of ethephon increased from 0 to 500 mg·L⁻¹. Ethephon delayed anthesis up to 10 days when applied at 500 mg·L⁻¹ and up to 8 days when applied at 250 mg·L⁻¹. The number of visible flower buds increased in all ethephon-treated plants compared to the control. Ethephon at 250 mg·L⁻¹, increased shoot and root dry mass 37.9% and 20.4%, respectively, compared to untreated controls. Roots appeared healthy in both experiments, but phytotoxicity (mild chlorosis) occurred in Expt. II on plants treated with 500 mg·L⁻¹. The experiment was repeated twice with similar results.

Effects of *Trichoderma harzianum* Strain T-22 Sprays on Incidence of Sooty Blotch and Fly Speck of Apple and Botrytis Fruit Rot of Raspberry

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Tests were made to determine the effectiveness of *Trichoderma harzianum* T-22 sprays in controlling sooty blotch (*Zygothiala jamaicensis*) and fly speck (*Gloeodes pomigena*) in five experimental scab-resistant apple varieties and botrytis fruit rot in five fall-bearing red raspberry cultivars. T-22 and S-12 surfactant used in these studies were supplied by BioWorks, Inc., Geneva, N.Y. Treatments applied to runoff on foliage and fruit were: unsprayed; T22 (1.2 g·L⁻¹), T22 + S-12 (1.2 g·L⁻¹ + 0.5 g·L⁻¹), Captan 50W +T22 (1.2 g·L⁻¹ + 1.2 g·L⁻¹), and Captan 50W

(1.1 g·L⁻¹). Raspberry treatments substituted Rovral for Captan 50W. Cultivars in the apple and raspberry trials were planted in a randomized complete block design with three blocks in the apple and four blocks in the raspberry planting. All spray treatments were applied to each cultivar in a block. Apples were treated on 5 Aug., 19 Aug, 2 Sept., and 16 Sept. and fruit were evaluated as cultivars ripened from 29 Sept. to 17 Oct. Raspberries were treated on 30 July (34% to 86% bloom), 14 Aug., 28, Aug., and 9 Sept. Evaluation for *Botrytis* was made throughout this period and data are presented for 12 Sept. Incidence of sooty blotch and flyspeck were ≈50% lower in T22 treatments than in unsprayed controls, but the difference was not significant. Captan treatments had significantly lower incidence of sooty blotch. Captan and T22 treatments had less flyspeck than the unsprayed controls, but the differences were not significant. Significant cultivar x treatment interactions may have resulted from the prolonged evaluation period and obscured differences in treatment effects. In the fall raspberries 10% of untreated, 5% of T22 and T22 + S-12-treated, and 2% of Rovral and Rovral + T22 fruit were infected with *Botrytis*. These differences were highly significant.

271

Bioremediation of Greenhouse Effluent using Constructed Wetlands

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Due to problems of water shortages and increased legal constraints concerning effluent content, nursery and greenhouse operations are in need of new methods of cleaning and reusing irrigation water. Using constructed wetlands to improve water quality is a low-cost and rapidly emerging ecotechnology, and is currently used for treating wastewater from cattle operations, catfish ponds, and residential subdivisions. To examine the effectiveness of constructed wetlands, a greenhouse was equipped with five free-standing wetland cells planted with *Equisetum hyemale* (Horsetail). Cells consisted of 0.9 x 2.4-m metal tanks filled with pea gravel (about 0.7 m deep) with inlet and outlet sampling ports. Each cell collected runoff from individual greenhouse benches stocked with impatiens or marigolds grown in pots containing Sunshine LC1 media and fertigated using trickle irrigation. Runoff flow rates and volume entering each cell were measured. Water samples were taken 1) directly from the irrigation line, 2) as bench crop runoff, 3) after entering the cell, and 4) after exiting the cell, and were analyzed for various N fractions. Preliminary studies indicated that the cell size used in these studies was sufficient to handle runoff volume from each bench and could reduce overall N concentration in the runoff. There was significant variability in effectiveness between the cells, which appears to be due to differences in cell vegetation growth and establishment. Overall evaluation of the system and recommendations will be discussed.

272

Use Yield Ratios to Evaluate Effects of Supplemental Pollination on Crop Production

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The environment caused large fluctuations in almond yields from year-to-year, which confounded analysis of pollination treatments performed in the field. Following the practice of supplemental pollination, there was insufficient improvement in yield to indicate that extra pollen applied to honey bees affected nut production. However, when yield for a cultivar exposed to extra pollen was compared to an untreated, reference cultivar grown in the same field, a statistically significant increase in yield was detected. Coefficients of variation for yield ratios averaged 54% lower than for yields alone in each of eight orchards examined. Converting annual yields to yield ratios mitigated the effects of the environment on analysis of production data.

273

Growth of Container-grown Plants With and Without Azomite Soil Amendment

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Azomite is a mined, commercially available, hydrated sodium calcium aluminosilicate soil amendment reported to act as a source of mineral elements. To determine its effect on plant growth, *Dendranthema* 'Connie' rooted cuttings, *Malus* seedlings, and *Citrus* seedlings were grown in containers in one of two growing media: ProMix BX or ProMix BX with Azomite (1:1, v:v). Plant height was

monitored weekly and after 6 weeks of growth, fresh and dry plant weights of roots and shoots were determined. There was no difference in any of the parameters measured as a result of the addition of Azomite. Any nutritional influence of the Azomite may only be evident in different conditions, e.g., field soil, or over an extended period of time. The Azomite altered the medium's physical properties and therefore bulk density and water-holding capacity of the Azomite were determined for consideration.

128 POSTER SESSION 3H (Abstr. 274–281) Breeding & Genetics—Germplasm & Genetic Diversity

274

Use of RAPD Fingerprints for Verification of Synonyms and Studies of Genetic Distance in Pear Genetic Resources

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Pear cultivars and clonal selections of five related *Pyrus* species or subspecies were "fingerprinted" using RAPD markers. Total DNA was extracted from young leaf tissue using a modified cTAB procedure. Twenty oligonucleotide decamers from Operon kits A and B were evaluated for repeatability and polymorphisms in an initial set of six cultivars. Nine highly polymorphic primers were selected for "fingerprinting" a larger set of 29 genotypes. Dissimilarity indices were computed from the RAPD markers, and cluster analysis performed on these genetic distance data. 'Jeribasma' and 'Vodenac', cultivars collected in Serbia, and 'Erabasma' collected in Poland, were verified as being synonymous genotypes. Cultivars from Eastern Europe were not uniformly grouped separately from cultivars from Western Europe. The results demonstrate the efficiency of RAPD markers for cultivar identification and studies of genetic relatedness.

275

The Plumeria Germplasm Collection of the University of Hawaii

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Founded in the mid-1960s to serve as a repository for the diverse plumeria (Family: Apocynaceae) varieties found in Hawaii, the collection has been moved twice and now occupies an area of 0.8 ha. Since the retirement of the plant breeder who initiated the collection, no active breeding program is in place, but the collection is augmented by donation of plumeria cuttings thought by their discoverers to have exceptional merit. The plant material is evaluated for habit of growth, susceptibility to rust, and for flower qualities including productivity, color, size, petal overlap, fragrance, and keeping quality. Recent accessions include several compact, evergreen plumerias with pink and yellow flowers showing both *Plumeria obtusa* and *P. rubra* parentage. Several plumeria cultivars developed in Texas have demonstrated positive qualities in the more favorable growing conditions of Hawaii. Several Hawaii accessions to be registered with the Plumeria Society of America in 1998 will be described and illustrated in this presentation.

276

Genetic Diversity of Basil (*Ocimum* spp. - *Lamiaceae*) Based on RAPD Markers and Volatile Oil Constituents

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Essential oils extracted from basil (*Ocimum* spp.) by steam distillation are used to flavor foods, oral products, in fragrances, and in traditional medicines. The genus *Ocimum* contains around 30 species native to the tropics and subtropics, with some species naturalized and/or cultivated in temperate areas. Inter- and intraspecific hybridization have created significant confusion in the botanical systematics of this genus. Taxonomy of basil (*O. basilicum*) is also complicated by the existence of numerous varieties, cultivars, and chemotypes within the species that do not differ significantly in morphology. In this study we are using RAPD markers and volatile oil composition to characterize the genetic diversity among the most economically important *Ocimum* species. We hypothesize that the genetic similarity revealed by molecular markers will more accurately reflect the

morphological and chemical differences in *Ocimum* than essential oil composition per se. Preliminary research using five *Ocimum* species, four undetermined species, and eight varieties of *O. basilicum* (a total of 19 accessions) generated 107 polymorphic fragments amplified with 19 primers. RAPDs are able to discriminate between *Ocimum* species, but show a high degree of similarity between *O. basilicum* varieties. The genetic distance between nine species and among 55 accessions within the species *O. americanum*, *O. basilicum*, *O. campechianum*, *O. x citriodorum*, *O. gratissimum*, *O. kilimandscharium*, *O. minimum*, *O. selloi*, and *O. tenuiflorum* will be analyzed by matrix of similarity and compared to the volatile oil profile. This research will for the first time apply molecular markers to characterize the genetic diversity of *Ocimum* associate with volatile oil constituents.

277

Affinities of *Rosa roxburghii* Tratt.

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Rosa roxburghii Tratt. has been placed in the monotypic subgenus *Platyrrhodon* (Hurst) Rehd. on the basis of its exfoliating bark and prickly hips (fruits). Several lines of evidence indicate a much closer relationship to species within the subgenus *Rosa* L., particularly to the species in the sections *Bracteatae* Thory., *Cinnamomeae* DC. and *Carolinae* Crep. Unlike *R. persica* Michx. (subgenus *Hulthemia* (Dumort.) Focke.) and *R. minutifolia* Engelm. (Subgenus *Hesperhodos* Cockerell), which inhabit deserts, *R. roxburghii* inhabits more mesic habitats alongside numerous species of subgenus *Rosa*. Chromosome morphology and size in *R. roxburghii* resemble those of subgenus *Rosa*, and both have a single nucleolar organizer locus on the short arm of a relatively short submetacentric chromosome, as revealed by fluorescent in situ DNA hybridization. *Rosa roxburghii* clustered well within subgenus *Rosa* on the basis of alleles at putative isozyme loci and RAPD markers. Thus *R. roxburghii* probably should be classified as a morphologically distinct section of the subgenus *Rosa* rather than as a separate subgenus.

278

Genetic Relatedness of Pecan Cultivars Determined by Using Random Amplified Polymorphic DNA (RAPD)

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Although pecan (*Carya illinoensis*) is an economically important nut and timber crop, little is known about the nature of genetic variation among pecan cultivars. In addition, the pedigree of many cultivars remains unknown or is questionable. In this study, the genomic DNA of 20 pecan cultivars were analyzed by RAPD, using 20 randomly selected oligos as primers. Based on their genetic similarities derived from the RAPD data, the 20 pecan cultivars were classified into different groups. Pecan cultivars within the same group displayed very little genetic variation, whereas cultivars in different groups showed significant diversity. The putative origins for some pecan cultivars previously believed to have unknown pedigrees were also identified based on the RAPD data obtained. Results of this study provide information useful for pecan cultivar classification and parent selection in pecan breeding programs.

279

Establishment of In Vitro Genebank of Colombian Cultivars of Achira (*Canna edulis* Ker.)

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Clonal propagation of an Andean tuber 'Achira' (*Canna edulis* Ker.) is currently limited to budding. A tissue-culture system to rapidly produce clonal material would be valuable for both production and germplasm preservation. Thirteen cultivars collected at the provinces of Caqueza (Cundinamarca) and Garzón (Huila) were utilized for the establishment of meristem-tips (5 mm) under in vitro conditions. Based on protocols reported for species of *Musa* sp., *C. indica* and *Elletaria cardamomun*, a complete random design was implemented with 10 treatments and six replications per clone. The analysis of variance showed no significant differences between cultivars, but significant differences among treatments. The

variables measured were number of shoots, aerial roots formation, roots (relative amount), callus (absent or present) and degree of etiolation. Double disinfection protocol was used in this study in order to reduce the degree of contamination of the explants during the culture. Organogenesis was obtained for the whole cultivars, without callus formation, with treatments 9 and 10. However the best results for shoot and root formation was detected for the treatment 10. This was constituted by MS (1/2) supplemented with 0.1 ppm BAP; 0.5 ppm IBA; 3% sucrose, and 2% phytigel. The explants were grown at 26 °C with photoperiod of 16 hours and 2000 lux. After 3 weeks the shoot formation was evident, while the rooting started after 4 weeks. Subcultures were done every 3 weeks after plantlets formation. The 13 cultivars established under in vitro conditions were placed at the active genebank of the Plant Genetic Resources National Program at CORPOICA, for their conservation under low growth conditions.

280

Calculation of Genetic Correlation Coefficients Based on Offspring-Parent Relationships Using a Spreadsheet

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Genetic correlation coefficients can be used to compare efficiency of direct and indirect selection, estimate correlated response to selection and set up index selection. Information on quantitative traits in parent and offspring can be used to estimate genetic correlation coefficients for fruit and nut crops. However, existing statistical packages do not allow easy calculation of genetic correlation coefficients. In this paper, we demonstrate the use of a spreadsheet to quickly estimate genetic correlation coefficients using data on parents and progeny in the OSU hazelnut breeding program. This procedure can be extended to n traits and m crosses.

281

The Introduction, Evaluation, Escape from Cultivation, and Ongoing Range Expansion of *Ligustrum* spp. On and Around the Texas A&M University Campus

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For decades, the Texas A&M Univ. campus has been a center for USDA ornamental plant introductions. Historically, horticultural nurseries on the Texas A&M Univ. campus have served as foci from which exotic plants have dispersed and colonized surrounding areas. *Pistachia chinensis*, *Ulmus parvifolia*, *Ligustrum quihoui*, *Ligustrum lucidum*, and *Sapium sebiferum* have all established themselves on or near the campus and can be traced back to early introductions. Many *Ligustrum* taxa including selections of *L. quihoui* were screened at Texas A&M College in the 1930s. Clones of this species varied greatly in their ability to naturalize. The invasion lag phase and range of expansion varied with both clone and species. It is suggested that potential exotic ornamental plant introductions be carefully evaluated for their potential to become non-native invasive species as well as for their ornamental characteristics.

128 POSTER SESSION 3I (Abstr. 282–285) Growth Regulators—Vegetable Crops

282

Involvement of Gibberellins in Phytochrome-regulated Stem and Petiole Elongation in Watermelon Plants

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Phytochrome-regulated stem and petiole elongation is of great horticultural importance due to their effects on height and compactness of plants. Although it is believed that phytochrome action during cell elongation is controlled via gibberellin (GA) biosynthesis, conclusive evidence has not been presented. In this study, watermelon plants pre-treated with GAs or GA biosynthesis inhibitors were briefly exposed to red (R) or far-red (FR) at the end of photoperiod to investigate the involvement of GAs in phytochrome-regulated stem and petiole elongation. Two-week-old watermelon plants were applied with either GAs, GA₃ (25 ppm) or GA₄₊₇ (25 ppm), or GA biosynthesis inhibitors, paclobutrazol (early stage inhibitor,

2 ppm) or prohexadione-Ca (late stage inhibitor, 200 ppm). Following chemical application, plants were treated with low-intensity R or FR light for 15 min at the end of photoperiod for 8 days. The increased petiole length and increased dry mass partitioned to petioles caused by FR were further increased when plants were pre-treated with GA₃ and GA₄₊₇, but reduced when plants were pre-treated with paclobutrazol or prohexadione-Ca. Pre-treatment with paclobutrazol or prohexadione-Ca further reduced the petiole length and dry mass partitioned to petioles caused by R alone, but effects of R were reversed when plants were pre-treated with GA₃ and GA₄₊₇. Petiole growth changes were significant after 2 to 3 days of treatments and there was no light or growth regulator effects on stem growth. Low leaf chlorophyll content and higher photosynthesis resulted in FR-treated plants were not observed when plants were pre-treated with paclobutrazol or prohexadione-Ca. Prohexadione-Ca was more effective in reversing FR induced petiole elongation than paclobutrazol, while GA₄₊₇ was more effective than GA₃ in promoting the effects of FR and reversing the effects of R. These results provide further evidence that phytochrome regulated growth changes in watermelon are due to the changes in GA biosynthesis. It is also suggestive that phytochrome has differential regulation of GA biosynthesis.

283

Influence of Methanol and Nitrogen on the Yield of Cilantro (*Coriandrum sativum*)

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Treatment with short-chain alcohols such as methanol and ethanol have been found to stimulate the performance of a number of crops. Container experiments were conducted in the Dominican Republic to determine the effect of methanol and nitrogen (N) treatments on the yield of cilantro (*Coriandrum sativum*). Plants were individually grown in plastic containers (15 x 15 cm) filled with loamy clay soil (4.3% organic matter) fertilized at planting with 20, 40, 60, and 80 kg N/ha. Methanol was sprayed in aqueous solutions (0%, 5%, 10%, and 15 %) when plants reached the three true leaf stage. A randomized complete-block design with a factorial arrangement and five replications was utilized. Cilantro plants were harvested 40 days after emergence and shoot fresh and dry weight were determined. Resulting data was subjected to analysis of variance and regression analysis. No significant nitrogen and methanol interactions were detected. In the range of rates tested in this study, methanol did not significantly influence cilantro shoot fresh or dry weight. Cilantro yields increased when N rates were increased from 20 to 40 kg per ha, reaching a plateau at higher N rates.

284

Responsiveness of Three Tayota (*Sechium edule*) Types to Gibberellic Acid Treatment

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Container experiments were conducted in the Dominican Republic to determine the effects of gibberellic acid applications on the 'White', 'Green', and 'Spiny Green' tayota (*Sechium edule*) Dominican types. Young plants (25 cm in length) of the three types were sprayed with aqueous solutions of gibberellic acid at rates 0, 50, 100, 150, and 200 parts per million. A completely randomized design with seven replications was utilized. Plant height and shoot dry weight were determined 30 days after treatment and resulting data was subjected to analysis of variance and regression analysis. Gibberellic acid treatment significantly increased tayota shoot dry weight and stem elongation. Both variables responded with similar patterns to gibberellic acid application. A linear regression ($Y = 39.82 + 0.214 X$, $r^2 0.95$) described stem elongation as a function of gibberellic acid rates. Results show that gibberellic acid can be effectively used in either tayota type to promote early stem elongation. From a practical standpoint, due to the climbing nature of *Sechium edulis*, rapid stem elongation could be instrumental in a more rapid establishment of the crop vines in the trellis system, as well as to provide the crop with an advantage on weeds competing for light during the usually critical early growth stages.

285

Effect of Ethephon on Tabasco Fruit Ripening

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The effect of ethephon on fruit maturity in tabasco pepper (*Capsicum frutescens* L.) was investigated in greenhouse studies. Two lines of tabasco pepper ('McHenry

Select' and 'Hard Pick') that differ in ease of separation at the calyx-pedicel separation zone were used. Individual flowers were tagged at anthesis and intact fruit were treated with ethephon (500, 1000 µL) 29, 32, 35, and 38 days after anthesis. Untreated fruit were used as controls. The normal development from anthesis to mature red is 45 to 47 days for both lines. Ethephon treatment to tabasco fruit of both lines at 29 and 32 days after anthesis was effective in enhancing ripening by 3 to 7 days. 'McHenry Select' ethephon treated fruit 35 days after anthesis were not affected. In contrast, 'Hard Pick' fruit treated with ethephon at the high rate (1000 µL) 35 and 38 days after anthesis resulted in enhanced ripening compared to that of the control. These results indicate that the two tabasco lines differ in response to ethephon.

128 POSTER SESSION 3J (Abstr. 286–296)

Sustainable Agriculture—Vegetable Crops

286

Crop Residues in San Joaquin Valley Row Crop Systems

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The West Side of California's San Joaquin Valley is one of the most productive agricultural regions of the world. The leading crops of this region include processing tomatoes, cotton, onions, garlic, cantaloupes, and lettuce, which are grown on over 570,000 acres annually. During the past 30 years, land use patterns on the West Side have changed considerably. More than 60% of the acreage in this area was typically planted to wheat, barley, and safflower in 1965, whereas in 1994 these crops were grown on 7% of the area. The intensification in the production of high value crops has led to fewer additions of organic matter to the soil and more aggressive tillage operations. In 1996–97, we quantified the amount and composition of postharvest crop residues that are returned to the soil in typical West Side rotations. The highest amount of crop residues resulted from corn stubble following grain harvest (10,300 lb dry matter per acre) and the lowest amounts resulted from onions and garlic, with 517 and 700 lb dry matter per acre, respectively. These data demonstrate the large range of organic matter recycling that results from various intensive cropping strategies in this region.

287

Cover Crops for San Joaquin Valley Row Crop Production Systems

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There is currently considerable interest in the use of cover crops to improve the productivity and sustainability of agroecosystems in California. Adoption of cover crops into San Joaquin Valley row cropping systems has been slow, however, largely because growth characteristics of potentially suitable cover crop species and mixtures have not been identified for the tight windows of opportunity that exist within the region's intensive rotations, and because of uncertainty about the amount of water required to grow a cover crop. In 1995–96 and 1997–98, we screened 15 potential late-summer and winter cover crop species and mixtures planted monthly from 1 Aug. through 1 Nov. and harvested at 30-day intervals through March. In 1995–96, Sorghum-sudan produced 36,543 lb dry matter/acre and was the highest-producing late-summer species in a December-harvested August planting. Triticale and Merced rye were highest-producing winter species, yielding 19,277 and 10,155 lb dry weight/acre, respectively, during the 5-month period from October to March.

288

Soil Nitrogen Movement under Sustainable Vegetable Production Systems

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An experiment was established to determine the effect of different tillage practices, vegetable crop rotations, and pest management strategies on crop yield, plant diseases, pest and beneficial arthropods, weed species changes over time, and soil environmental consequences. This poster describes nitrogen movement from

the various treatments over a 3-year rotation. The treatments are: 1) conventional tillage with chemically based IPM; 2) conventional tillage with biologically based IPM; 3) conservation tillage with chemically based IPM; 4) conservation tillage with biologically based IPM; and 5) conventional tillage with no fertilizer or pest management. Mid-season soil analyses with depth showed chemical-fertilized plowed and conservation-tilled treatments with more soil available nitrogen at most depths compared to the biological-based IPM systems (soybean meal was used as a nitrogen source). However, the biological-based systems did supply enough soil nitrogen to produce similar yield results as the chemical-based systems. Less soil nitrate was measured in the 30- to 90-cm depths at harvest from the biological-based systems than chemical-based systems. Conservation-tilled systems had greater nitrate with depth compared to conventional-tilled systems.

289

Nitrogen Assimilation and Biomass Yield of Winter Cover Crops Used in Sustainable Horticultural Crop Production

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Cover crops are planted during winter to prevent soil erosion, improve soil quality, and supply nutrients to the subsequent spring crops. In a 2-year study, three winter cover crops were compared for their nitrogen assimilation and biomass yielding ability. The experimental design was randomized complete block replicated four times with cereal rye, hairy vetch, crimson clover, and a fallow control comprising the treatments. Cover crop roots were well distributed from 1 to 50 cm of soil depth and increased from fall to spring as temperature increased. There was greater reduction in soil inorganic N during fall and winter in cover crop plots compared to control. Early season soil NO_3^- concentration was lower in rye than crimson clover or hairy vetch. The amount of N assimilated by hairy vetch and crimson clover was significantly greater than cereal rye or control. There was no difference in the biomass yield of the three cover crops during the first year, but cereal rye and crimson clover produced significantly greater biomass than hairy vetch during the second year. The results suggest that cereal rye is more suited for preventing leaching of residual N from the preceding summer crop, while the two legumes can supply more N to the following crop.

290

Weed Control in Tomato Production using Spring-sown Cover Crops Killed by Undercutting

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A cover crop study in Spring 1996 showed that mowing did not completely kill the cover crops. In 1997 the study was repeated with the same cover crop treatments using winter rye 'Wheeler' (*Secale cereale*) and field peas (*Pisum sativum*). Cover crops were established in pure stands and bi-cultures in decreasing levels and varying proportions in early Spring 1997. They were undercut under the soil 2 months later, prior to transplanting tomato seedlings. Three controls were included in each replicate. Tomato plants in treatments with higher seeding rates of field peas had higher leaf areas and dry weights 1 month after transplanting. Weeds, especially dicotyledons, grew through the cover crop mulch 1.5 months after undercutting, but by then the tomato plants were at an advanced stage of growth. Tomato fruit yields were much higher than those of 1996 and had significant differences ($P = 0.05$). Highest yields were from treatments with highest rates of 0.25 rye + 0.75 peas, 0.5 rye + 0.5 peas, pure peas, and the conventionally hand-weeded control. Lowest yields were from the weedy checks. Undercutting the cover crops improved yields in all plots so treated probably because the soil was loosened and the tomato plants' roots accessed nutrients and water better. Spring sowing and undercutting cover crops definitely has a potential for weed control.

291

Yield and Nutrient Uptake of Peppers (*Capsicum annuum*) Grown with Dairy Manure Compost and Fertigated Nitrogen

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The use of compost as an organic source of nutrients and soil improvement may help to increase the sustainability of intensively managed vegetables. Bell pepper (*Capsicum annuum* L.) transplants were planted into silver-colored polyethylene mulched beds in a sandy loam soil amended with 0 or 22.4 $\text{Mg}\cdot\text{ha}^{-1}$

dairy manure compost. Preplant P was added to all beds at 78 $\text{kg}\cdot\text{ha}^{-1}$. During the season, N (as NH_4NO_3) was added about every 10 days. Total N rates for the season were: 0, 32, 65, or 96 $\text{kg}\cdot\text{ha}^{-1}$. Percent of N in pepper leaf tissue increased from a low of 2.7% without N to 3.8% at the high N rate. Leaf P concentrations were higher in 0 N plots than in other rates. Compost resulted in higher leaf concentrations of Ca. There was an interaction of compost and N rates for percent of culls. Compost increased percentage of culls with 0 or 32 $\text{kg}\cdot\text{ha}^{-1}$ N, but decreased or did not affect cull percentage at 65, or 96 $\text{kg}\cdot\text{ha}^{-1}$ N. Compost did not affect other yield parameters measured. Marketable yields increased from 11 $\text{Mg}\cdot\text{ha}^{-1}$ with 0 N to 18 $\text{Mg}\cdot\text{ha}^{-1}$ with high N, although the regression was not significant, due to extreme variability within the field.

292

Sustainable Production of Honeydew and Muskmelon in Western Mexico

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In Western Mexico, melon production depends on high-input systems to maximize yield and product quality. Tillage, plasticulture, fumigation with methyl bromide, and fertigation, are the principal management practices in these systems. However, at present several problems has been found: pests as sweetpotato whitefly (*Bemisia tabaci* Gennadius), aphids (*Myzus* and *Aphis*), leafminer (*Liryomiza sativae*); diseases as Fusarium, Verticillium, and Pseudoperonospora, and weeds demand high pesticide utilization and labor. There is a growing demand for alternative cultural practices, with an emphasis on reducing off-farm input labor and chemicals. Our research is based on use of organic mulches, such as: rice straw, mature maize leaves, banana leaves, sugarcane bagasse, coconut leaves, and living mulches with annual legume cover crop in melons with crop rotation, such as: *Canavalia*, *Stilozobium*, *Crotalaria*, and *Clitoria* species. Also, inoculations with mycorrhizal arbuscular fungi for honeydew and cantaloupe melon seedlings production are been assayed in greenhouse conditions for a transplant system. The use of life barriers with sorghum, marigold, and other aromatic native plants in conjunction with a colored yellow systems traps for monitoring pests is being studied as well. While that the pest control is based in commercial formulations of *Beauveria bassiana* for biological control. The first results of this research show that the *Glomus intraradices*, *G. fasciculatum*, *G. etunicatum*, and *G. mosseae* reached 38.5%, 33.5%, 27.0%, and 31.0% of root infection levels, respectively. Honeydew melons production with rice and corn straw mulches shows a beneficial effect with 113.30 and 111.20 kg/plot of 10 m^2 compared with bare soil with 100.20 kg . The proposed system likely also lowers production cost and is applicable to small- and large-scale melon production.

293

Conservation Tillage of Winter Broccoli in a Semi-arid Sub-tropical Environment

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Winter broccoli (*Brassica oleracea*, L. Botrytis Group) production was evaluated under three tillage systems, conventional (CT), minimum tillage (MT), and no-till (NT), which were established in Aug. 1994. Cotton, followed by a legume, preceded broccoli in the yearly rotation. After three growing seasons, marketable broccoli yields were similar among tillage systems, but plant densities at harvest were lower in the NT system compared to the CT-grown broccoli plants. No-till-grown broccoli heads compensated for stand differences by producing slightly larger heads ($P = 0.17$). The percent marketable yield was not affected by tillage practice. Floret NO_3^- , chlorophyll, and carotenoid concentrations were reduced when broccoli was grown by conservation tillage (MT and NT). At the end of the third growing season, the amount of germinable weed seeds in the upper 0-5 cm of soil was highest in the NT soil. Total plant weed populations were higher in conservation tilled soil. Total N, K, and Mg concentrations in the upper 30-cm soil profile were highest in the NT system. Total N, C, K, Mg, and P nutrient gradients were greatest in NT soil, whereas Na concentrations were greatest in CT soils. Min. tillage responses were generally intermediate to those of CT and NT.

294

Relationship Between Cover Crop Growth, Weed Suppression, and Yield of No-tillage Broccoli (*Brassica oleracea* L. var. *italica*)

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In 1997, no-till fall broccoli was grown at the Kentland Agricultural Research Farm (KARF), Blacksburg, Va., and the Beltsville Agricultural Research Center (BARC), Md., to determine supplemental N requirements above the nitrogen contribution from legume in situ mulches. Treatments were tillage systems [CT = conventional tillage, bare soil, tilled prior to transplanting; NT-BS = untilled bare soil; NT-SB = soybean (*Glycine max* L.) cover crop; and NT-CP = cowpea (*Vigna sinensis* Endl.) cover crop; and nitrogen fertilizer rates (0, 84, and 168 at KARF, and 0, 56, 112, and 168 kg·ha⁻¹ at BARC). All plots at both sites were treated with recommended herbicides and drip irrigated as needed to supplement rainfall. Dry weight soybean and cowpea biomass was 6.1 and 4.3 at KARF and 4.8 and 3.5 t·ha⁻¹ at BARC. In N-unfertilized plots at both sites, average broccoli yield was higher in NT-SB and NT-CP than CT and NT-BS. The N contribution from the legume mulches was inadequate to meet total crop demand, since N fertilizer applications increased broccoli yield in all tillage treatments, including the legume cover crops (soybean and cowpea). In N-fertilized plots, broccoli yield was similar among tillage treatments at KARF where weed problems were not severe; however, at BARC, yield in CT was higher than in all no-till treatments. Weed pressure was considerably lower in CT than in no-till plots at BARC. Based on these data and other related no-till studies, two conclusions can be drawn: a) no-till systems are a viable option for production of broccoli when weeds are adequately controlled; and b) uniformly distributed, high-residue levels are required for weed suppression when weed pressure is high and herbicides are either ineffective or not applied.

295

Tillage and Mulch Effects on Yield of Bell Pepper (*Capiscum annum* L.)

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In 1997, three tillage/mulch pepper production systems were compared on raised beds at the Beltsville Agricultural Research Center (BARC), Md., and at Kentland Agricultural Research Farm (KARF), Blacksburg, Va. The tillage/mulch treatments were no-till hairy vetch (*Vicia villosa* Roth) mulch (NT-HV), black plastic mulch on beds that were conventionally tilled and reformed before transplanting the peppers (CT-BP), and untilled bare soil (NT-BS). 'Camelot' bell peppers were planted in early June 1997 in double rows at both sites. Both the CT-BP and NT-BS treatments received approximately double the nitrogen fertilizer, compared to NT-HV. Nitrogen was applied throughout the growing season at BARC, while all the N fertilizer was applied during the first 3 weeks of plant growth at KARF. Nine weekly harvests were made at BARC and six at KARF. Fruit yield was high in all treatments at both sites. There were no significant differences among treatments in marketable yield or fruit weight at BARC. In contrast, yield was significantly higher with CT-BP than with NT-HV and NT-BS at KARF. Higher yield with CT-BP at KARF possibly occurred from enhanced soil temperature and reduced N leaching normally associated with black plastic mulch production systems.

296

Composted Chicken Manure Improves Growth and Yield of Red Table Beets

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Six on-farm trials were conducted from 1995–1997 to test the effects of composted chicken manure applications on stand establishment, growth, disease incidence, and yield of red table beets (*Beta vulgaris*). Yields were consistently higher (14% to 68%) in plots where 4500 or 9000 kg·ha⁻¹ composted chicken manure was broadcast at planting. Compost applications improved early season stands in 1995 and 1996; however, emergence and seedling death occurred throughout the season in all trials. The number of marketable beets at harvest was as low as 35% of the number of seeds planted, even when yields were above average. Applying composted chicken manure to red table beets offers a way to use a waste product from one agricultural production system as an input in another, thus improving efficiency and minimizing pollution.

128 POSTER SESSION 3K (Abstr. 297–305) Crop Production/Postharvest—Fruit

297

Re-evaluation of a Desiccating Surfactant for Thinning Peach Blossoms

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The surfactant "Surfactant WK" (dodecyl ether of polyethylene glycol) was applied to peach trees [*Prunus persica* (L.) Batsch] at full bloom over 3 years. Blossoms died rapidly, so that within 2 days dead blossoms could be distinguished easily from live blossoms or set fruit. There were strong ($R^2 > 0.87$), linear correlations between concentration of "Surfactant WK" applied and percent blossoms removed and fruit set, which were similar over the 3 years. Trees were hand-thinned according to commercial practices after treatment. There was similar cropload, fruit weight and yield across treatments at harvest indicating no negative effects by the chemical on productivity. There was only slight limb damage at the highest concentrations of "Surfactant WK", which over thinned blossoms. We recommend that based on the effectiveness, consistency, and lack of significant phytotoxicity, "Surfactant WK" be re-evaluated as a thinning chemical for peach trees.

298

Thinning Peaches with Dormant Applications of Soybean Oil

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Dormant applications of 0% to 20% soybean oil were tested as a prebloom thinner of 'Georgia Belle' and 'Redhaven' peach flower buds. Five separate experiments were conducted with soybean oil applied in late Jan. or early Feb. 1992, 1993, 1995, and 1997. The number of living and dead flower buds was counted on five or 10 shoots per tree before and 1 month after application in Expts. 1, 2, 3, and 4. In Expt. 5, buds were counted on two to three shoots per tree before and after a freeze of -4 °C during petal fall. Soybean oil thinned flower buds in all five experiments. The amount of flower bud death was concentration dependent with maximum bud kill of 53% occurring with application of 12% oil. Thinning was fairly consistent from year to year, ranging from 34% to 51% when 10% oil was applied, but was less uniform when 5% oil was applied and ranged from 6% to 40%. Overthinning occurred in Expt. 3 by all oil concentrations tested. Bud death in untreated trees was 40% in this experiment indicating that no thinning was needed. Mild to moderate spring freezes occurred in Expts. 2, 4, and 5, but did not result in greater yield loss in thinned than untreated trees. Soybean oil at 10% and 12% resulted in greater flower bud survival of a freeze in Expt. 5. Dormant applications of soybean oil thinned flower buds, reduced the amount of hand thinning and hastened fruit maturity.

299

Effect of Upright Shoot Removal on Fruit Size and Maturity of Four-year-old 'Braeburn' Apple Trees

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The effect of upright shoot removal on the progress of maturity and fruit size around the normal picking time were evaluated for apple fruits cv. 'Braeburn' at the Experimental Farm of the Comahue National Univ., Rio Negro, Argentina, during the 1996–97 growing season. The experiment was conducted on 4-year-old trees, spaced 4.0 x 2.3 m and trained to palmette leader. Average fruit load was 80 fruits per tree. Five trees per treatment were randomly selected; they were: 1) select cuts: water sprouts were eliminated entirely at 78 days after full bloom (DAFB) and additional removal of newly formed shoots arising from the scaffolds was performed at 120 DAFB; 2) control: trees received no cuts. From 158 to 184 DAFB, a sample of four fruits was taken from each tree at weekly intervals. Fruit size and internal quality were measured. Loss of leaf surface by shoot removal significantly decreased fruit mass by 4.74%, for all data combined ($P < 0.05$). There was no treatment effect on maturity, although the rate of firmness decline was lower for fruit from treated trees. At 172 DAFB, pressure, starch index (iodine test) and soluble solids concentration values for control fruits were 80.55 N, 3.72

and 12.35%, respectively. In the treated trees, fruit mass was 201.03 g at final harvest. It was concluded that reduction in photoassimilates following severe upright shoot removal may be a key factor in the negative effect of this practice on final fruit size. These results suggest some goals of pruning and training for optimizing apple yield.

300

Evaluation of Endothall and Ammonium Thiosulfate as Potential Bloom Thinning Compounds for 'Delicious' and 'Fuji' Apples

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Consistent cropping of apple under Pacific Northwest growing conditions depends on a reliable bloom-thinning compound. Although there are two commercially available bloom-thinning chemicals, performance of these chemicals is not always consistent. Research on two unregistered bloom thinning compounds, Endothall and ATS, has been ongoing for several years in commercial orchard blocks. In 1997, multiple applications of Endothall and ATS were tested on 'Delicious' and 'Fuji'. Endothall was applied at 1.0, 1.5 or 2.0 pints/100 gal per acre rates at 40% and 80% full bloom. Endothall averaged 19 to 23% thinning in comparison to the water control on 'Delicious'. With 'Fuji', Endothall averaged 55% to 83% thinning. ATS was applied at 1.0% (v/v) on 'Delicious' and 1.5% (v/v) on 'Fuji' at 40% and 80% full bloom. ATS thinned 'Delicious' an average of 30% compared to the water control. In 'Fuji', ATS thinned an average of 20% to 42%. Another experiment involved the combination of ATS or Endothall with standard postbloom thinning regimes. Fruit quality data were collected on both bloom and postbloom thinned blocks. Differences in fruit size and shape were significantly correlated with NAA applications. No significant differences in soluble solids, titratable acidity, skin color, or flesh firmness were related to thinning treatments.

301

Ethephon Alters the Physiology of Young Apple Fruits

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Methods are needed to quickly assess the efficacy of chemical thinning treatments, so, if needed, additional treatments can be applied. When fruit diameter averaged 19 mm, 'Smoothie' trees were sprayed with Ethrel at the rate of 3.7 ml formulation/L to induce abscission of most fruits on the tree. The diameter of 10 fruit/tree were measured daily and fruits were sampled 2, 4, and 6 days after treatment (DAT) to evaluate fruit development. Fruit on nontreated trees increased in diameter at the rate of about 0.7 to 0.9 mm/day. Fruit growth on treated trees was normal for 1 day, slowed to 0.5 mm for 2 days, and grew <0.1 mm/day thereafter. Fruit water potential was less negative for treated trees 2 DAT. Fresh and dry mass of treated fruit ceased increasing after 4 DAT. Percent dry mass of control fruit declined on each sampling date, but did not decline for treated fruit after 4 DAT. Cellulase was active in the abscission zone 4 DAT for treated fruit, but not control fruit. Compared to control fruit 6 DAT, treated fruit had elevated respiration and less starch accumulation. Fruits began to abscise 6 DAT. Following Ethrel application. The first indication that a fruit is destined to abscise are reduced fruit growth and changes in water potential 2 DAT.

302

Effects of Fruit Bagging on Accumulation of Anthocyanin, Flavonoid, and Simple Phenols at Harvest and on Anthocyanin Synthesis Potential During Storage in 'Delicious' Apples

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'Delicious' fruit were covered with paper bags from the early development stage until harvest at the Horticultural Center, Univ. of Massachusetts. Bagging did not affect fruit maturity, but significantly affected phenolic composition in fruit peel. Compared with the control, bagged fruit did not accumulate anthocyanin, but contained low levels of procyanidin and quercetin glycosides and relatively large amounts of simple phenolic acids. When bagged, fruit were re-exposed to light; they started to accumulate anthocyanin quickly and anthocyanin accumulation reached maximum after 3 days of light exposure. The potential of anthocyanin synthesis in bagged fruit remained constant during 5 months of cold storage. Results indicate that accumulation of anthocyanin, procyanidin, quercetin glycosides, and simple phenolic acids has different light requirement and these fruit could be

a useful model in the research on anthocyanin synthesis and gene expression in apples.

303

Effect of a Single Defoliation and Fruit Thinning on Papaya Fruit Production and Quality

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The effect of defoliation and fruit thinning on papaya fruit set, growth, and ripe fruit quality was determined. Three defoliation levels (0%, 50%, 75%) and two defoliation methods (75% leaf cut off from the oldest to the youngest vs. 75% leaves removed in a spiral from the oldest) was compared with fruit thinning experiment on 'Sunset' papaya during the warm season. Removal of 75% of the leaves significantly reduced new flower and fruit set, and decreased TSS level in ripe fruit. There was no significant difference between 0% and 50% defoliation in new fruit set, or ripe fruit TSS levels. Removal of leaves in a spiral reduced the number of new flower and fruit set more than the defoliation from the bottom to top. Defoliation of the 'Kapoho' variety increased ripe fruit number and significantly reduced ripe fruit TSS and sugar level, dry mass percentage 2 weeks after defoliation. There was no significant difference between defoliated and non-defoliated treatment in fruit production, average fruit mass, and percentage of fruit flesh and seed, seed mass ratio, and seed dry mass during the test period. Fruit thinning increased new fruit set and increased ripe fruit TSS level in Line-8 and 'Sunset', but not in 'Kapoho'. However, average ripe fruit mass increased in fruit thinning experiment in 'Kapoho' but not 'Sunset' and Line-8 varieties. Fruit thinning also increased remaining young fruit TSS and sugar levels on the remaining fruit on plants compared to same-aged fruit on control and defoliated plants in Line-8. There was no effect on 'Kapoho' young fruit TSS and sugar levels of defoliation. Ripe fruit TSS varied with weather conditions, plant growth conditions, and cultivars. These results indicated that although different cultivars had different responses to artificial defoliation and fruit thinning, source-sink balance and the ratio of fruit to leaf was an important factor in controlling potential fruit production and final fruit quality.

304

Fruit Removal and Continual Defoliation Altered Papaya Fruit Production and Quality

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The source size and sink strength were modified by continual defoliation and fruit removal in 'Sunset' papaya. Flower and fruit set, mature fruit mass, and TSS was recorded weekly. Fruit at four different stages of development were harvested at the end of the experiment. Fruit mass, respiration, sugar content, and sucrose phosphate synthase (SPS), sucrose synthase (SS), and invertase enzyme activities were compared. Continual defoliation resulted in lower new fruit set (25% of control), smaller fruit size (77% of control), and lower TSS (85% of control) in the 24-week experimental period. In contrast, there were 52% and 100% more new fruit when fruit were removed than in the control within the first 8 weeks and 24 weeks, respectively. Larger fruit size, earlier fruit development, lower respiration, and higher sugar contents were observed when fruit were removed at 140, 154, and 175 days from anthesis. No significant difference was found in TSS level in the mature fruit compared to the control. Fruit removal plus defoliation gave the same number and mass of new fruit as the control and slightly lower TSS in mature fruit than in the control. Fruit sugar was higher with increased fruit invertase activity and fruit age. Data confirmed that source-sink balance was critical for fruit set, development, and sugar accumulation in papaya.

305

Urea Combined with 6-Benzyladenine Applied to the Foliage of Pistachio Trees during Nut-fill Reduced Floral Bud Abscission during the "On" Crop Year and Increased Yield the Following "Off" Crop Year

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Alternate bearing of pistachio (*Pistacia vera* L. cv. Kerman) is a significant problem in California. Excessive abscission of floral buds beginning in June and

intensifying at the time of seed development (nut-fill) in July during the "on" year results in the next year's "off" crop. While the mechanism resulting in alternate bearing in pistachio has been identified, its physiological basis has not and there is no satisfactory horticultural practice to even out alternate bearing. Bud retention in pistachio was increased 3-fold and 2-fold for two successive years, respectively, on branches bearing greater than 70 nuts per cluster (an "on" crop) basal to the shoot bearing the buds for next year's crop with foliar applications of 0.25% N as low-biuret urea combined with 25 mg 6-benzyladenine per liter applied in early June and early July. In Sept. 1997, the crop produced by the buds treated in 1996, an "on" crop year, was harvested. The untreated control trees produced an "off" crop, 7.6 kg fruit per tree, yielding 0.5 tons split nuts (dry weight) per acre. Trees treated with 0.25% N as urea combined with 25 mg 6-benzyladenine per liter on June 1 and July 1 yielded 16.4 kg fruit per tree, resulting in 1.14 tons split nuts (dry weight) per acre ($P \leq 0.05$).

128 POSTER SESSION 3L (Abstr. 306–312) Growth/Development/Nutrition—Citrus/ Subtropical

306

Citrus Carbohydrate Levels were Related to Irrigation Frequency but Not Arbuscular Mycorrhizal Fungal (AMF) Inoculum

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Sugar and starch concentrations in leaves and roots of *Citrus volkameriana* Tan and Pasq were measured in response to irrigation frequency and AMF inoculum. Non-mycorrhizal seedlings were treated with a soil inoculum from one of five different communities of AMF; two AMF communities from Arizona citrus orchard soils, and three communities from undisturbed desert soils. Plants were assigned to frequent (soil water tension > -0.01 MPa) or infrequent (soil water tension > -0.06 MPa) irrigation cycles and were container-grown in a glasshouse for 4 months before tissues were analyzed. Fungal inoculum source did not affect shoot or root carbohydrate levels. Plants grown under high irrigation frequency had increased leaf and root starch levels and increased root sugar levels compared with those under low irrigation frequencies. High irrigation frequency also increased shoot mass.

307

Crease (Albedo Breakdown) can be Predicted by Peel Thickness and Peel Nutrient Status as Early as the End of the Cell Division Stage of Fruit Development

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Crease is a rind disorder of economic consequence to the citrus industry. The literature suggests crease is related to the thickness of the peel at maturity and nutrient status of the tree, especially N, P, and K, which are known to influence peel thickness. Our objective was to quantify the interrelationship between the degree of crease in an orchard at harvest and September leaf nutrient concentrations, as well as peel nutrient concentrations at maximum peel thickness. The 2-year experiment was conducted at seven California 'Valencia' and navel orange (*Citrus sinensis* L. Osbeck) orchards with known differences in the incidence of crease. Maximum peel thickness, which occurs at the end of cell division during fruit development, was significantly negatively correlated with percent crease at harvest for all sites in both years. There was no significant correlation between leaf N, P, or K concentrations and maximum peel thickness or crease. There was a significant negative correlation between peel K concentration and percent crease for all sites in both years. There was a weak correlation between the incidence of crease and peel nitrogen content in both cultivars. Peel P concentration was not correlated to the incidence of crease in either cultivar. These data identified threshold values for maximum peel thickness and peel K concentration at maximum peel thickness below which the incidence of crease would be greater than 10% for both cultivars.

308

Field Measurements and Simulation of Nitrogen Fate under Citrus Production

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Water and nitrogen (N) are important inputs for most crop production. The main objectives of nitrogen best management practices (NBMP) are to improve N and water management to maximize the uptake efficiency and minimize the leaching losses. This requires a complete understanding of fate of N and water mass balance within and below the root zone of the crop in question. The fate of nitrogen applied for citrus production in sandy soils (>95% sand) was simulated using a mathematical model LEACHM (Leaching Estimation And Chemistry Model). Nitrogen removal in harvested fruits and storage in the tree accounted the major portion of the applied N. Nitrogen volatilization mainly as ammonia and N leaching below the root zone were the next two major components of the N mass balance. A proper irrigation scheduling based on continuous monitoring of the soil water content in the rooting was used as a part of the NBMP. More than 50% of the total annual leached water below the root zone was predicted to occur in the rainy season. Since this would contribute to nitrate leaching, it is recommended to avoid N application during the rainy season.

309

Nutrient Concentrations in Soil Solution in an Alfisol under Grapefruit Production

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A field experiment was conducted in a Riviera fine sand (Alfisol) with 25-year-old 'White Marsh' grapefruit trees on Sour orange rootstock to monitor the downward transport of nutrients from fertilization practices. Fertilizer was applied as either dry granular broadcast (three applications/year) or fertigation (15 applications/year) at N rates of 56, 112, 168, and 336 kg/ha per year using a N:P:K blend (1.0:0.17:1.0). Soil solution was sampled bi-weekly from suction lysimeters, installed under the tree canopy, about 120 cm from the tree trunk, at two depths representing above (120 cm) and below (180 cm) the hard pan. The concentrations of K, Ca, and Mg were greater at the 180- than at 120-cm depth, whereas, the converse was true with respect to the concentration of P in soil solution. Over a 2-year period, the mean concentrations of P and K varied from 0.031-0.976 and 150-250 mg·L⁻¹, respectively. Increased rate of fertilization also appeared to increase the concentrations of Ca and Mg in the soil solution. This could be due to effects of slight acidification of the soil with increased rates of ammonium form of N. A parallel study on pH measurements has shown evidence of soil acidification, under the tree canopy, with increased rates of ammonium fertilization. In a bedded grove, the soil solution above the hard pan is likely to seep into the water furrow, which is discharged into the drainage water.

310

Impact of Nitrogen Management Practices on Total Nitrogen in the Fruits of High Productive Hamlin Orange Trees

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For perennial crop production conditions, major portion of nutrient removal from the soil-tree system is that in harvested fruits. Nitrogen in the fruits was calculated for 22-year-old 'Hamlin' orange (*Citrus sinensis*) trees on Cleopatra mandarin (*Citrus reticulata*) rootstock, grown in a Tavares fine sand (hyperthermic, uncoated, Typic Quartzipsamments) that received various N rates (112, 168, 224, and 280 kg N/ha per year) as either i) broadcast of dry granular form (DGF; four applications/year), or ii) fertigation (FRT; 15 applications/year). Total N in the fruits (mean across 4 years) varied from 82 to 110 and 89 to 111 kg N/ha per year for the DGF and FRT sources, respectively. Proportion of N in the fruits in relation to N applied decreased from 74% to 39% for the DGF and from 80% to 40% for the FRT treatments. High percentage of N removal in the fruits in relation to total N applied at low N rates indicate that trees may be depleting the tree reserve for maintaining fruit production. This was evident, to some extent, by the low leaf N concentration at the low N treatments. Furthermore, canopy density was also lower in the low N trees compared to those that received higher N rates.

Girdling Lemons to Improve Fruit Size and Set in Southern Arizona

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Arizona lemon producers are often concerned with poor flowering, fruit set and fruit sizing, especially following excessively warm winter or spring weather. 'Limoneira 8A Lisbon' (*Citrus limon* Burm.) lemons were girdled over a 3-year period to determine if girdling would improve yield or fruit size. Eight trees were girdled each month, from November through August, using a double spiral girdle and a 4.8-mm wide girdling knife. Fruit size measurements were taken throughout the growing season. Trees were harvested individually, and yield; fruit packout and fruit quality measurements were collected. For the 1995/96 harvest, trees girdled in March and May had greater early size and greater yields. Fruit quality was improved as well. For 1996/97 harvest year, trees girdled the previous November and December had significantly greater yield and fruit size. For trees harvested in 1997/98, no treatment was significantly better than the non-girdled trees. The effects of girdling on the orchard profitability will also be discussed.

312

Substrate pH and Papaya Seedling Growth

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Two studies were conducted to determine the influence of pH on 'Waimanalo' papaya seedling growth and morphology. The seedlings were grown in clear, plastic tubes with diameter of 7 cm and length of 21 cm, and substrate was silica sand. The substrate was drenched daily with complete nutrient solution. The solution was adjusted to pH of 3, 4, 5, 6, 7, 8, or 9. We used direct-seeded plants in the first study, and plants were harvested following 9.5 weeks of growth. We used transplants in the second study, and plants were harvested following 4 weeks of growth. Dry mass of plants was relatively unaffected by substrate pH within the range of 4 to 9. In both studies; however, dry mass of plants receiving solution with a pH of 3 was reduced. The response pattern was similar for canopy:root ratio, total root length, root growth rate, lateral root thickness, and root tip density. Unit leaf area per unit root length was greatly increased for plants receiving pH of 3, indicating increased susceptibility to drought conditions.

128 POSTER SESSION 3M (Abstr. 313–322) Breeding & Genetics—Breeding for Genetics of Resistance

313

Potato Lipoxigenase *POTLX-3* Gene is Expressed In Response to Pathogens but Not Wounding

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Lipoxygenases are the first committed enzymes in biosynthetic pathways that produce jasmonic acid, methyl jasmonate, traumatin, fatty acid hydroperoxides, and volatile aldehydes. These pathways often function in growth- and defense-related processes in plants. Products of lipoxygenases may be the primary cause of the hypersensitive response (HR) because lipoxygenase by-products such as organic free radicals and active oxygen species are involved in cell membrane degradation during resistance responses against pathogens. In order to study lipoxygenase involvement in defense responses against pathogens, we have isolated and characterized a potato lipoxygenase gene that we have designated *POTLX-3*. *POTLX-3* is not expressed in any potato organs, is not induced by wounding, but is strongly induced in leaves treated with ethylene, methyl jasmonate, or inoculum of *Phytophthora infestans*, the causal agent of potato late blight. In response to infection, *POTLX-3* transcripts accumulate more rapidly in resistant lines than in susceptible lines. In resistant lines, the greatest amount of induction preceded the visual appearance of localized necrotic lesions, consistent with possible involvement of *POTLX-3* in HR development. Expression of *POTLX-3* also is activated in response to inoculation with the bacterial pathogen *Pseudomonas syringae* pv. *phaseolicola*, which causes strongly expressed HR

in all potato cultivars. Thus, *POTLX-3* expression is not a specific response to *P. infestans*, but rather a common response related to HR development against a broad range of pathogens. Pattern of *POTLX-3* expression indicates that it may have a specific role in defense mechanisms against pathogens.

314

Development of Five Tropically Adapted Disease Resistant Dry Bean Varieties

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Diseases are a primary constraint affecting yield and seed quality of dry beans (*Phaseolus vulgaris*) in the Dominican Republic. A collaborative dry bean breeding program to develop resistance to one or more diseases in different dry bean types was conducted in the Dominican Republic (DR) under a US-AID Title XII Bean/Cowpea CRSP involving breeders and pathologists in the Ministry of Agriculture, DR, Univ. of Nebraska, Lincoln, and the Univ. of Puerto Rico, Mayaguez. The origin and some characteristics of the five new dry bean varieties released in 1988 are described here. The black seeded 'Arroyo Loro Negro' (MUS-N-4-H) (Type II a growth habit) was derived from the cross H-270 (MSU/UPR) X XAN-223 and has resistance to web blight and rust. The pedigree of the white seeded 'Anacaona' (L-8020) (Type II a growth habit) is (2b-5-1/2 x NEP-2/Black Turtle Soup) X BON 355 (MSU). 'Anacaona' is moderately resistant to web blight. The three red-mottled determinate Pompadour varieties were developed from the following crosses: 'Saladin-97' (PC-21-SME) and 'CIAS-95' (PC-21-SMA) from 'PC-50' (DR) X BAT 1274 (CIAT) and 'JB-178' (PR-JB-178) from 'Jose Beta' (DR) X C1308 in Puerto Rico. These new high yielding Pompadour varieties have a higher level of field resistance to Andean pathotypes of rust in the DR than does 'PC-50' the predominate variety.

315

Gene Estimation, Associations of Traits, and Confirmation of QTL for Common Bacterial Blight Resistance in Common Bean

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Common bacterial blight, incited by *Xanthomonas campestris* pv. *phaseoli* (*Xcp*), is a serious disease of common bean (*Phaseolus vulgaris* L.). Gene estimation, associations of traits, and confirmation of QTL for resistance to *Xcp* were investigated in a recombinant inbred population derived from the backcross BC₂F₆ PC-50 (susceptible to *Xcp*) x XAN-159 (resistant to *Xcp*). One or two genes from XAN-159 controlled leaf resistance to *Xcp*. One major gene from XAN-159 was involved in controlling pod resistance to *Xcp*. Low (+0.24) to intermediate (+0.57 and +0.75) Pearson correlations were observed between leaf and pod reactions to *Xcp*. Purple flower color was associated with leaf and pod resistance to *Xcp* but not days to flower. One to 2 QTLs explained from 20 to 51% of the total phenotypic variation for leaf reactions to 5 *Xcp* strains. Two QTLs explained from 20 to 22% of the total phenotypic variation for pod reactions to *Xcp* strains EK-11 and DR-7. A marker BC437.1050 was associated with leaf and pod resistance to 5 *Xcp* strains in nearly all experiments, and accounted for 13% to 45% of the phenotypic variation for these traits. A unassigned marker D13.1000 was associated with only pod resistance to *Xcp* strains EK-11 and DR-7. Gene number (1 or 2) estimations and number of QTL (1 or 2) detected for resistance to *Xcp* generally agree. The confirmed marker BC437.1050 is expected to be useful in breeding programs for resistance to *Xcp*.

316

Genome Mapping in *Citrullus* Populations Segregating for Fusarium Wilt Resistance

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Fusarium wilt, caused by the soilborne fungus *Fusarium oxysporum* f.sp. *niveum* (FON), is one of the most economically important diseases of watermelon (*Citrullus lanatus*) worldwide. FON has been divided into three races (races 0, 1, and 2) determined by differential pathogenicity assays. Most commercial cultivars

are resistant to races 0 and 1; whereas none are resistant to race 2. Few morphological and isozyme variations are seen in the cultivated watermelon, but molecular markers, such as random amplified polymorphic DNA (RAPD), amplified fragment length polymorphisms (AFLPs) and simple sequence repeats (SSRs), have been shown to generate several polymorphisms. Segregating populations, derived from a cross between watermelon cultivar New Hampshire Midget, susceptible to all three races of FON and the resistant *C. lanatus* plant introduction PI 296341, were used to detect molecular markers linked to Fusarium wilt resistance. In a preliminary experiment, more than 180 10-mer primers were screened against the parents and the F₁. Informative RAPD primers were identified and used in conjunction with AFLP and SSR markers to generate a genome map.

317

Molecular Markers Linked to *Phytophthora fragariae* Resistance Genes in Strawberry

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The commercial strawberry (*Fragaria x ananassa* Duch.) is susceptible to red stele root rot caused by the fungus *Phytophthora fragariae* Hickman var. *fragariae*. Characteristics of the disease are the reddened steles and "rat tail" appearance of the roots. Infected plants are dwarfed, exhibit wilting, and eventually die. Red stele resistance in strawberries and virulence of *P. fragariae* behave according to the gene-for-gene system. Resistance genes and their corresponding avirulence genes have been identified by screening plant roots for infection. The goal of this international research project with CPRO-DLO, The Netherlands, is to develop highly specific molecular markers for various *Rpf* resistance genes (*Rpf1*, *Rpf2*, *Rpf3*, and *Rpf6*) that confer resistance against *P. fragariae*. Bulked Segregant Analysis was used to identify RAPD and AFLP markers putatively linked to *P. fragariae* resistance genes. The bulked DNAs representing subsets of three F₁ populations that segregated monogenically for either resistance or susceptibility to *P. fragariae*. The map of these *Rpf* loci was generated using JoinMap®. The RAPD markers linked to the resistance genes are being converted into SCAR markers, while the AFLP markers will be used as probes for the detection of *P. fragariae*. The application of the molecular markers linked to resistance genes will have direct applicability to strawberry breeding programs. Marker-facilitated selection of these resistance genes would allow an efficient means in the screening and selection of plant material containing these genes and help in the pyramiding for resistance to *P. fragariae*. Genetic improvement of the strawberry by the ability to pyramid resistance genes will contribute to the productivity of the strawberry industry worldwide.

318

Breeding for Leafminer Resistance within the Genus *Betula*

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The birch leafminer (*Fenusa pusilla*) is an important insect pest of white-barked ornamental birches (*Betula* spp.). Although genetic resistance to birch leafminer exists within this genus, it has not been identified in the desirable white-barked species. Twenty-three interspecific crosses were performed in an attempt to combine ornamental white bark and leafminer resistance. The parental species and resulting hybrid populations were assayed for resistance. All assays utilized adult birch leafminers reared in our laboratory using a method we developed to provide a year-round supply of fresh leafminer adults. Previous studies viewed birch leafminer resistance as the unwillingness or inability of the female leafminer to oviposit eggs into the leaves of resistant *Betula* species. Our work has shown that female birch leafminers are unable to distinguish between suitable and non-suitable host species. This work also has discovered two separate mechanisms of inherent resistance to the birch leafminer: leaf chemistry and a hypersensitive response. Two native species, *B. alleghaniensis* and *B. lenta*, kill the leafminer larvae shortly after hatching. Analyses suggest that a specific compound or class of compounds is responsible for leafminer mortality in these species and that this resistance is reduced in F₁ hybrids that include a susceptible white-barked parent. The second resistance mechanism involves a hypersensitive response to the deposition of the leafminer egg and results in failure of the egg to hatch. Interestingly, this response is seen in one of our breeding lines (*B. populifolia* x *B. maximowicziana*), but has not been observed in either parental species. These hybrid progeny are currently in field test plots for further evaluation of leafminer resistance and ornamental characteristics.

319

Identification of a Source of Resistance to Cherry Leaf Spot

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Cherry leaf spot caused by *Blumeriella jaapii* (Rhem) Arx. is a major fungal disease of sour cherry in most of the world's sour cherry production areas. This fungus causes premature defoliation, which, in conjunction with low temperature winter injury, can result in death of limbs and entire trees. 'Montmorency', the only major sour cherry cultivar grown in the United States, is highly susceptible to this fungus and numerous fungicides are required to prevent this disease. In 1996, sour cherry seedlings and GI 148-1, a triploid hybrid developed in Germany from the cross sour cherry (*Prunus cerasus* Schattenmorelle) x *P. canescens* (Schmidt and Gruppe 1988 HortScience 23: 112), were inoculated with spores of *B. jaapii* obtained from infected sour cherry leaves in the orchard. Lesion counts were taken on days 7 and 14 and the number of lesions per cm² was calculated. This experiment was repeated in 1997, including a full sibling of GI 148-1, GI 148-2. Sour cherry and GI 148-2 were highly susceptible to cherry leaf spot. Within 14 days, these selections exhibited an average of 19.4 and 5.4 necrotic lesions per cm² respectively, sporulation, chlorosis, and eventually leaf drop. In contrast, GI 148-1 had significantly fewer lesions on average (1.4 lesions per cm²), no apparent sporulation, chlorosis or leaf drop. Different reactions exhibited by siblings GI 148-1 and GI 148-2 suggest that the resistance gene(s) in 148-1 are on the *P. canescens* chromosome(s), not from the sour cherry parent, and that the *P. canescens* parent was not homozygous. GI 148-1 is currently being used in a backcross breeding program to develop resistant varieties.

320

Inheritance of Resistance to the Southern Root-knot Nematode in *Capsicum chinense* Jacq.

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A series of greenhouse tests were conducted to compare the level of resistance to the southern root-knot nematode (*Meloidogyne incognita*) exhibited by recently released *Capsicum chinense* germplasm lines to the level of resistance exhibited by *C. annuum* cultivars, to determine the inheritance of the resistance in *C. chinense*, and to determine genetic relationship between the resistances exhibited by *C. chinense* and *C. annuum*. The results of a replicated test indicated that the level of resistances exhibited by the recently released *C. chinense* germplasm lines PA-353, PA-398, and PA-426 is equal to the level of resistances exhibited by the resistant *C. annuum* cultivars Mississippi Nemaheart and Carolina Cayenne. Evaluation of parental, F₁, F₂, and backcross populations of the cross PA-426 x PA-350 indicated that the resistance in *C. chinense* is conditioned by a single dominant gene. The results of an allelism test indicated that this dominant gene is allelic to the *N* gene that conditions southern root-knot nematode resistance in the *C. annuum* cultivar Carolina Cayenne. The availability of a simply inherited source of outstanding resistance makes breeding for southern root-knot nematode resistance a viable objective in *C. chinense* breeding programs. This objective should be readily obtained by the application of conventional plant breeding methodologies.

321

A New Virus-tolerant Southernpea

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Southernpea (cowpea), *Vigna unguiculata* L. Walp, is an important processing and fresh-market vegetable in the southern United States. Several varieties are available for growers, but there are very limited numbers that combine bush plant type, earliness, good processing quality and virus resistance. A single plant selection from the variety 'Excel' offers this combination of traits. The breeding lines 87-435-68 is a single plant selection from the variety 'Excel' that was made on the basis of its reaction to blackeye cowpea mosaic virus (BLCMV). The resistance mechanism is somewhat different than the traditional varieties with single gene resistance to BLCMV. The reaction to BLCMV is manifested as tolerance rather than classical single gene immunity.

322

Pathogenic Variation in Halo Blight on Common Beans

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Halo blight, caused by a bacterium, *Pseudomonas syringae* pv. *phaseolicola* (*Psp*), is one of the most important bacterial diseases of common beans (*Phaseolus vulgaris* L.). The objective of this study was to evaluate the pathogenic variation of *Psp* strains with emphasis on those collected in Nebraska. Twenty-nine *Psp* strains were inoculated on 20-day-old leaves of eight differential cultivars/lines and a resistant check line great northern (GN) Nebraska #1 sel. 27. Two experiments were conducted in growth chambers under 20 °C and 12-h photoperiod. A split-plot design was used with nine cultivars/lines as whole plots in a randomized complete block design (RCBD) and strains as sub-plots in an incomplete block arrangement. Data were analyzed as a split-plot with a RCB arrangement because incomplete block was not significant. Strains were classified into five races with six, 16, and two strains classified as races 1, 6, and 7, respectively. The remaining strains were designated tentatively as new races 10 and 11. GN Nebraska #1 sel. 27 was resistant to all *Psp* strains tested. This information is useful to breeders interested in developing germplasm and cultivars resistant to *Psp*.

128 POSTER SESSION 3N (Abstr. 323–326) Crop Physiology/Mycorrhizae—Cross- commodity

323

Alleviation of Phosphorus Stress on *Capsicum annuum* L. cv. San Luis (Chile Ancho pepper) with a Mixed *Glomus* spp. from Mexico and *Glomus intraradices*

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The effect of a mixed isolate of arbuscular mycorrhizal (VAM) fungi [*Glomus* spp. from Veracruz, Mexico] and a pure isolate of *Glomus intraradices* was assessed on the growth and gas exchange of 'Chile Ancho' (*Capsicum annuum* L. cv. San Luis) under phosphorus (P) stress. The experiment was carried out under glasshouse conditions in 1-L plastic pots containing a pasteurized mixture of 1 sand : 1 sandy loam (v/v). Plants were inoculated or noninoculated with VAM. Plants were fertilized with a modified Long Ashton nutrient solution (LANS) containing 0 or 11 (g phosphorus/ml). Gas exchange measurements were taken 21 and 70 days after the experiment was initiated. Mycorrhizal plants at both 0 and 11 (g P/ml) had greater leaf area, fruit, root, stem and leaf dry mass, and a lower specific leaf area and root/shoot ratio than nonmycorrhizal plants. Nonmycorrhizal plants not supplied with P had a higher leaf area ratio than plants colonized with *G. intraradices*. Net photosynthesis and stomatal conductance were not consistent with growth responses. There were no significant differences in growth and gas exchange between the two mycorrhizal isolates.

324

Influence of Mycorrhizal Fungi on Growth and Nutrient Uptake of Micropropagated Guava Plantlets (*Psidium guajava* L.) during Acclimatization and Plant Establishment

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The effect of mycorrhizal fungi on growth and nutrient uptake during acclimatization and plant establishment of micropropagated guava plantlets (*Psidium guajava* L. cv. Media China) was determined. Half of the plantlets were inoculated with the endomycorrhizae isolate ZAC-19 and grown in a glasshouse for 18 weeks. The isolate ZAC-19 was collected from the Chihuahuan Desert in Zacatecas State, Mexico, and is a mixed isolate containing *Glomus etunicatum* and unknown *Glomus* spp. Plantlets were fertilized with modified Long Ashton nutrient solution containing 11 µg P/ml. Shoot length, leaf area, leaf number, and dry mass partitioning were positively affected by mycorrhizae compared to noninoculated plantlets; however, noninoculated plantlets had greater leaf area ratios and specific leaf area. Mycorrhizal plantlets generally had increased leaf tissue mineral levels, particularly P, Mg, Cu, and Mo. However, noncolonized plantlets had higher N, K, and Mn. At the end of the experiment, roots of inoculated guava plantlets had colonization levels of 94.3%.

325

Effect of Mycorrhizal Fungi on Gas Exchange of Micropropagated Guava Plantlets (*Psidium guajava* L.) during Acclimatization and Plant Establishment

Andrés A. Estrada-Luna*, Jonathan N. Egilla, and Fred T. Davies, Jr.; Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133 USA

The effect of mycorrhizal fungi on gas exchange of micropropagated guava plantlets (*Psidium guajava* L.) during acclimatization and plant establishment was determined. Guava plantlets (*Psidium guajava* L. cv. 'Media China') were asexually propagated through tissue culture and acclimatized in a glasshouse for eighteen weeks. Half of the plantlets were inoculated with ZAC-19, which is a mixed isolate containing *Glomus etunicatum* and an unknown *Glomus* spp. Plantlets were fertilized with modified Long Ashton nutrient solution containing 11 (g P/ml). Gas exchange measurements included photosynthetic rate (A), stomatal conductance (g_s), internal CO₂ concentration (C_i), transpiration rate (E), water use efficiency (WUE), and vapor pressure deficit (VPD). Measurements were taken at 2, 4, 8 and 18 weeks after inoculation using a LI-6200 portable photosynthesis system (LI-COR Inc. Lincoln, Neb., USA). Two weeks after inoculation, noninoculated plantlets had greater A compared to mycorrhizal plantlets. However, 4 and 8 weeks after inoculation, mycorrhizal plantlets had greater A, g_s, C_i and WUE. At the end of the experiment gas exchange was comparable between noninoculated and mycorrhizal plantlets.

326

Influence of Selected Endomycorrhizae from the Sonoran Desert and *Glomus intraradices* on Growth Response and Gas Exchange of *Hibiscus rosa-sinensis* L. cv. Leprechaun

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Six endomycorrhiza isolates from the Sonoran Desert of Mexico [Desert-14(18)1, 15(9)1, 15(15)1, Palo Fierro, Sonoran, and *G. geosporum*] were evaluated with a pure isolate of *Glomus intraradices* for their effect on the growth and gas exchange of *Hibiscus rosa-sinensis* L. cv. Leprechaun under low phosphorus fertility (11 mg P/L). Rooted cuttings of *Hibiscus* plants were inoculated with the seven mycorrhiza isolates and grown for 122 days. Gas exchange measurements were made on days 26, 88, and 122 after inoculation, and plants were harvested on day 123 for growth analysis. Plants inoculated with the seven isolates had 70% to 80% root colonization at harvest. Plants inoculated with *G. intraradices* had significantly higher leaf, shoot and root dry matter (DM), leaf DM/area ($P \leq 0.05$) than those inoculated with any of the six isolates, and greater leaf area (LA) than Desert- 15(9)1 and 15(15)1. Uninoculated plants had significantly lower leaf, shoot, root DM, leaf DM/area and LA ($P \leq 0.05$) than the inoculated plants. There were no differences among the seven isolates in any of the gas exchange parameters measured [photosynthesis (A) stomatal conductance (g_s), the ratio of intercellular to external CO₂ (C_i/C_e), A to transpiration (E) ratio (A/E)]. The relationship between inoculated and uninoculated plants in these gas exchange parameters were variable on day 122 after inoculation.

128 POSTER SESSION 3O (Abstr. 327–334) Extension

327

A Survey of Nursery Water Quality Best Management Practices

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A survey was designed to assess high-risk areas with respect to environmental contamination, specifically how it relates to water quality. Oklahoma growers of all economic levels, retail and/or wholesale, were queried at their place of business for their current state of implementing best management practices (BMPs) and other strategic actions that could potentially affect current and future water quality standards. Specific areas such as the physical environment of the nursery, primary pesticides and fertilizers used, Integrated Pest Management (IPM) practices, and

employee safety training were covered as well as other aspects germane to preserving and protecting current water quality and related environmental issues. More than 75 nurseries were surveyed and given the opportunity to participate in future training at Oklahoma State Univ. Results indicated that nurseries have not fully implemented many BMPs, but have adopted fundamental IPM approaches. The stage is set for the implementation of the next phase of expansion and refinement into ecologically based programs such as propagation and sale of low pesticide input plant materials, improved cultural practices, and the integration of environmentally sound management approaches. As an example, many growers are in the process of phasing out calendar-based pesticide application programs in favor of aesthetic and/or economic threshold-driven pesticide spray programs.

328

Surveys Show Extension Workshops Improve Floridians' Adoption of Environmental Landscape Management Practices

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Environmental Landscape Management (ELM), an extension education program, approaches every landscape as a "system" in which cultural practices interact with each other and the environment. ELM guidelines integrate site conditions, landscape design, plant selection, cultural factors, and recycling in a comprehensive, environment-friendly strategy for managing a landscape. Use of ELM practices by Floridians will conserve resources and protect the environment. The ELM program was evaluated from 1992 to 1994 in 10 counties to measure the program's impact on participants' landscape practices and to provide information on ways to improve program delivery and effectiveness. The evaluation was accomplished by comparing pre-program information on the use of ELM practices with that of a follow-up conducted 6 months after the program. Responses of this Program Group (n = 473) were compared to those of a Comparison Group of randomly selected Floridians (n = 186). ELM training increased the Program Group's adoption of most practices pertaining to pest management, irrigation, and mowing and pruning. ELM training increased adoption of some fertilization practices and a few recycling and wildlife practices. Energy conserving practices were not widely used by respondents. Respondents maintaining their own yards or those without a permanent irrigation system were more likely to adopt a wide range of ELM practices. The Program Group generally had higher initial levels of adoption of ELM practices than the Comparison Group.

329

Implementing Bio-intensive IPM Systems in Cling Peaches

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A complete mating disruption program that uses pheromone confusion technology successfully controlled oriental fruit moth and peach twig borer while eliminating most in season insecticides in cling peaches from 1995-1997 in a three-county area. During this 3-year period, 46 cooperators used this program on 580 acres. Growers applied both Oriental fruit moth and peach twig borer pheromone dispensers twice. Orchards were monitored for moths and for shoot strikes during the season. Harvest samples were taken to determine worm damage. A few orchards were sprayed once when shoot strike counts exceeded threshold levels of three to five strikes per tree. Along with mating disruption in 1997, 209 acres were sprayed with *Bacillus thuringiensis* during bloom to replace the dormant insecticide spray and improve efficacy of pheromone confusion. Throughout implementation, mating disruption program costs were compared with conventional spray programs. Between 1995 and 1997, the complete mating disruption program cost decreased from \$243 per acre to \$216 per acre respectively. Even with the decrease in cost, this is much higher than \$104 per acre for the standard spray program. Some growers decreased pheromone dispenser applications in 1997 for a more economic program. This program still reduced pesticide use by 33% to 67%. While most growers using this partial program had success, some orchards had high shoot strikes indicating a potential problem. Grants from USDA-ES-Smith-Lever IPM project, EPA Environmental Stewardship Partnership, California Department of Pesticide Regulation and Farm Service Agency cost share programs aided in our ability to implement these bio-intensive programs; they provided the money necessary for monitoring and reducing direct costs to the grower. The main obstacle to cling peach growers adopting the complete bio-intensive program is the economics. Most growers will continue to spray or

use a partial mating disruption program until less expensive commercial products become available.

330

Maryland's Home and Garden Information Center: Helping Residents Solve Pest, Plant, and Landscape Problems

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The Home and Garden Information Center was created by the Univ. of Maryland Cooperative Extension Service in 1989 to relieve county-based faculty of the growing burden of client requests for help in the home horticulture area. The Center inter-disciplinary staff includes four regional specialists, phone consultants and office support personnel. The Center's twin goals are to educate residents to make wise decisions regarding horticultural practices and pesticide and fertilizer use and to help clients self-diagnose their pest and plant problems. These goals are achieved through a variety of outreach methods and advanced technologies. A conversant phone system allows residents toll-free access (24 hours a day) to pre-recorded, self-help, problem diagnostic tapes. Horticulture consultants are available Monday through Friday, 8 a.m.-1 p.m., to provide personalized phone service to individual clients. The phone system has handled over 320,000 calls in 8 years. A 1997 phone survey showed a client satisfaction rating of over 90%. Center faculty produces a well-received Master Gardener Handbook with extensive diagnostic keys and writes phone tapes and newspaper articles. The "IPM Series" of peer-reviewed fact sheets, enables clients to use diagnostic keys to identify and solve plant problems. Residents can also access information through the Center's web site which includes updated subject matter tips, and "pages" for the Master Gardener program, Bay Issues and plant diagnostic keys. Center faculty also helps to train phone consultants, county horticulture consultants, and Master Gardeners.

331

Analysis of Residential Horticultural Questions Answered by Master Gardeners

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An analysis of commonly asked horticultural questions is being conducted by the Office of Environmental Horticulture at Virginia Tech in order to improve the question and answer process between Master Gardeners and the public. Records of questions received by Master Gardeners from a sampling of Extension offices representing all growing areas of the state are being sorted and categorized to identify the most frequently asked questions and develop a electronic resource to assist in answering those questions quickly and with consistent IPM based information. More than 4000 questions have been analyzed and organized in to the following categories: Plant Questions (specific type or species of plant), General Gardening Questions (composting and fertilizing, herbicides and pesticides, soil testing etc.), Program Questions (Extension programs, Master Gardener program), and Animal and Insect Questions. The plants questions have been further divided into the sub-categories. The animal and insect questions have been sorted by species type with the percentage asked of each calculated. This information is posted on a web site and is linked to additional resources for answers. The address is www.hort.vt.edu/mastergardener/Q&A.html. The site contains useful information, links, and opportunities for feedback via e-mail.

332

An Annotated Pest Management Database with Field Decision-making Guides for the Mid-Atlantic Region

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Integrated Pest Management (IPM) information is available in various forms to help cooperative extension agents and private consultants. Scouting forms, manuals, fact sheets, bulletins, and books have been written over the past few years to cover all aspects of IPM. Some of this information has not been published or is no longer available and can only be obtained from the authors. This makes it difficult to obtain historical or even new information. A Northeast Region Sustain-

able Agriculture Research Education (SARE) grant was received to evaluate and improve delivery systems for integrated crop and pest management. As part of the grant, a searchable database was created in FileMaker Pro™ so individuals can search for information on a specific crop or pest. There are 1580 entries covering 49 vegetables, 12 field crops, and three small fruits. Each entry has a summary and key words; where and how to obtain the document; crops and pests included; the audience for the publication, e.g. extension agent, researcher, agribusiness, gardener, etc.; and the type of publication, e.g. fact sheet, website, scouting form, etc. All categories within the database are searchable with pull down screens where appropriate. The database is integrated with a series of laminated field decisionmaking guides. These 2-page guides contain information on the damaging stage of the pest, monitoring stage, sampling methods, sampling frequency and thresholds. Information included in the field guides comes mainly from research in the mid-Atlantic region. Additional information related to the crop or pest can be obtained by searching the database by the use of key numbers listed in the guide. Each database entry has a key number for identification. The field guides are being validated in 1998 and both will be available in late 1998.

333

Volunteer Management Reference for Local VCE Master Gardener Coordinators

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Virginia Cooperative Extension's (VCE) Master Gardener volunteer program is available in 72 unit offices. The unit programs are managed by MG coordinators who currently include 10 locally funded agents, eight locally funded technicians, and 28 volunteers. The VCE Master Gardener Coordinator Manual, a 12-unit resource book, was developed cooperatively with teams of MGs, coordinators, and agents to enhance coordinators' skills for managing the local VCE MG program. The manual includes chapters on VCE MG components such as risk management; job descriptions; recruitment and screening; and volunteer review, recognition, and retention. Additional resources within the manual include a synopsis of educational program planning, implementation, and evaluation, as well as a copy of the current VCE Master Gardener Program Policies and the volunteer section of the Virginia Master Gardener Handbook, which serves as program orientation for new or prospective trainees. The VCE Master Gardener Coordinator Manual is the basis of three local MG coordinator training sessions in 1998. Additional resources available to coordinators for enhancing the local MG program include a MG newsletter focused on the role of Master Gardeners as community leaders and educators; program policies and guidelines for the management of MG training and operation; VCE publication 426-699 Welcome to Virginia Master Gardening! Guide to Educational Programming and Resource and Reference Guide; and the VCE Master Gardener Internet website at <http://www.ext.vt.edu/vce/specialty/envirohort/mastergard/master.html>.

334

Instructor Attitudes toward Interactive Television for Training Master Gardeners at a Distance

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Master Gardener training was delivered via interactive television (IT) or face-to-face (FTF) in 1996 and 1997. Following 1997 training, instructors were surveyed to determine if the method of program delivery influenced their perceptions of Master Gardener training. Most instructors preferred FTF program delivery as compared to IT training. More preparation time was spent in developing lecture notes, text slides, and visual aids for IT vs. FTF training. Although instructors were more comfortable with FTF training than IT programming, their comfort level with IT training increased with experience. A major reason for instructor discomfort with IT was the lack of personal contact with trainees. Although lack of interactivity was identified as a limiting factor with IT training, trainees monopolizing time during sessions was a major constraint for FTF training. In spite of instructor preference for FTF Master Gardener training, nearly all instructors indicated a willingness to teach IT training again. Motivating factors for future IT training included less night time instruction, less need to travel, job efficiency, and the opportunity to use new technology.

26 ORAL SESSION 1 (Abstr. 335–339)

Woody Ornamentals/Landscape/Turf— Crop Production

335

Vegetative Propagation of Woody Ornamentals Through Forcing of Epicormic Shoots

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A propagation method is being developed that allows softwood shoots to be generated from stem sections of dormant woody plant species. These shoots, forced in the greenhouse during the winter, are subsequently collected and processed as softwood stem cuttings to produce clonal plant material. Many species in the nursery industry can only be propagated using softwood cuttings, and this technique allows propagation of these species to be initiated several months earlier than what is typically possible. Current studies involve expanded screening of ornamental tree and shrub species to determine if commercial production using this technique is feasible. Results demonstrate that many species may be propagated using this method, but that some species are more prolific than others with respect to number of softwood shoots produced. Additional studies are currently in progress to determine the environmental (light regime, moisture regime) and cultural (type of media) conditions that are optimal when producing clonal plant material via this technique.

336

Effect of Growth Regulators on Rooting of *Magnolia grandiflora* Cultivars

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Cuttings from three southern magnolia cultivars, 'Claudia Wannamaker', 'Greenback™', and 'Little Gem', were treated with KIBA, KNAA, and Hormodin #3, separately and in combination, at varying concentrations. The rooting of cuttings was cultivar-dependent, with 'Greenback™' responding significantly to all the treatments. Only the high KNAA and combination treatments were effective with 'Little Gem' and 'Claudia Wannamaker'. The effect of KNAA on rooting with increasing concentration was significant. No similar response was observed with KIBA. The combination treatment with quick dip plus the talc formation produced the greatest rooting and root quality with the three cultivars. With this treatment, the average rooting rate of three cultivars was 67.4%, whereas the rooting rate of control plants was only 11.8%.

337

Rooting Softwood Cuttings from Forced Stem Segments of Adult White Ash

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On 10 Apr. 1997, the smaller branch on forked *Fraxinus americana* L. (white ash) trees in an 8-year-old clonal plantation were removed, cut into 25-cm-long stem sections, and placed horizontally in perlite under seven different forcing regimes. Sprouts from latent buds were excised 67 and 99 days later and trimmed to retain the apical pair of leaves and terminal bud. The basal 2 cm of each cuttings was set for 30 to 60 min in one of six aqueous dilutions made from a stock solution of 1% IBA and 0.5% NAA (Dip 'n Grow) before placing in a 1 perlite : 1 vermiculite medium. Eight weeks after treating, cuttings data were collected. Most cuttings treated with 3200 mg/L IBA plus 1600 mg/L NAA quickly died. Survival (85%) and rooting percentage (86%) were similar for the remaining auxin-treated cuttings and controls with water only. Cuttings treated with 1600 mg/L IBA plus 800 mg/L NAA produced the most adventitious roots (6.2 roots), the longest adventitious root (22 cm), and longest combined sum of all adventitious roots (51 cm); however, these rooted cuttings died when transplanted to soil. Cuttings treated with 100 mg/L IBA plus 50 mg/L NAA or 400 mg/L IBA plus 200 mg/L NAA had more adventitious roots (3.2 roots) and total length of adventitious roots (370 mm/cutting) than cuttings treated with 40 mg/L IBA plus 20 mg/L NAA or

controls with water only (2.2 roots, 220 mm long). Results indicate softwood cuttings forced on stem segments of adult white ash readily root under mist following a brief soak in a 400 mg/L IBA plus 200 mg/L NAA solution.

338

Propagation of *Thuja* x 'Green Giant' by Stem Cuttings: Effects of Growth Stage, Type of Cutting, and IBA Treatment

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Stem cuttings of *Thuja* L. x 'Green Giant', consisting of 22-cm terminals or 20-cm laterals, were collected on three dates associated with specific growth stages (softwood, semi-hardwood, and hardwood), and treated with indolebutyric acid (IBA) in 50% isopropanol ranging from 0 to 9000 ppm and placed under intermittent mist. Regardless of cutting type or auxin treatment, cuttings rooted in high percentages at each growth stage. Overall rooting was highest for hardwood cuttings (96%) followed by semi-hardwood (86%), and softwood (85%) cuttings. Semi-hardwood cuttings were the only cuttings in which rooting was affected by IBA or cutting type with the greatest rooting (94%) attained using lateral cuttings treated with 6000 or 9000 ppm IBA. Although an interaction occurred between IBA treatment and cutting type for mean root length of hardwood cuttings, only mean root length of semi-hardwood cuttings was influenced by IBA concentration alone with the greatest length (25 mm) achieved with 6000 ppm IBA. An interaction was noted for root count between cutting type and IBA concentrations for softwood cuttings, whereas IBA and cutting type affected independently root count on semi-hardwood cuttings. Treatment with 9000 ppm IBA resulted in 18 roots per rooted cutting whereas lateral cuttings responded with a mean of 16 roots over all IBA concentrations. Root count on hardwood cuttings was affected by IBA treatment only, with 9000 ppm being optimum (14 roots per rooted cutting).

339

Below-ground Pot-in-Pot (PIP) System and Substrate Moisture Regimen Affect Growth of Two Desert Trees

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Acacia smalli (sweet acacia) and *Cercidium praecox* (palo brea) trees were grown during June–Oct. 1997 outdoors in full sun in 19-L containers positioned either PIP or above ground on the soil surface. The 38-L PIP holder containers were placed in the ground. Cyclic pulses of water were controlled by soil moisture sensors interfaced with electronic solenoid irrigation valves. Rooting substrate water potentials at 20 cm below the substrate surface and 10 cm inside the container wall were consistently maintained at either >-0.01 MPa (wet) or between -0.02 and -0.03 MPa (dry) for both above ground and PIP container substrates. Less than 1.25 cm of rainfall occurred during the study period. No incidences of rooting-out were observed with PIP trees. Maximum root-zone temperatures of PIP containers were 19 °C lower than temperatures measured in substrate of above-ground containers. Growth of both species was stimulated by the wet substrate regimen compared with the dry regimen. Positioning trees in a below-ground PIP configuration under the wet substrate regimen stimulated growth of sweet acacia compared with the PIP dry regimen. The PIP configuration did not affect growth of palo brea trees.

27 ORAL SESSION 2 (Abstr. 340–345) Human Issues in Horticulture

340

Schools, Children, and Gardening: The Results of a Children's Garden Competition among Florida Elementary Schools

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Children's contact with nature is slowly diminishing as we progress towards a more technology-orientated society. While computers and other technology provide students with valuable skills, children are becoming more detached from nature and the unique opportunities nature can provide. School gardens

offer teachers and students a "down to earth," hands-on approach they might not otherwise gain in the classroom. In Spring 1998, the Univ. of Florida in conjunction with the 1998 Epcot® International Flower and Garden Festival hosted a competition for the best elementary school garden among Florida elementary schools. The competition called for schools to construct or use an already existing garden and for teachers to incorporate the garden in their classroom instruction. Approximately 100 elementary schools throughout Florida participated in the competition. From these schools a random sample of 500 students were selected to answer an environmental attitude survey. Students completed the survey at the beginning of the spring semester and at the completion of the competition in April to examine the effects of the garden competition on their environmental attitudes. In addition, teachers were asked to complete a survey detailing the use of the garden in their classroom and the effect it had on their students. This session will discuss the details of the competition, the findings and implications of the competition, and suggestions on how to promote student and school participation in similar horticultural programs.

341

Studying Children's Perceptions of Garden Benefits Using the Internet

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A survey was designed to investigate children's perceptions of the benefits of gardening and is posted on the KinderGARDEN Web page within the Aggie Horticulture network. The KinderGARDEN Web page was developed as a resource for parents and teachers to help them incorporate the garden into the home and school lives of children. The Web site additionally attracts young visitors with a "Fun Page." The "Fun Page" has descriptions of garden activities that children can experiment with at home or school, garden literature for children and garden Web links. The survey is included on this page. Children respond to the survey via e-mail. The survey requests information about the type of gardening situations in which each respondent participates, the number of children with whom they generally garden, what they feel they learn from gardening and what benefits they feel they gain from gardening. Children responded positively on the value of the garden to their recreation, while also mentioning educational, environmental, aesthetic, social and economic benefits in the survey. Results showed that 81% of children felt they were learning about the environment by working in the garden. Fifty-four percent of children mentioned that the garden taught them about plants and plant-related concepts. Other benefits children mentioned as important to them included recreation and/or "having fun" (31%) and socialization with friends and family (15%).

342

Plant Biotechnology Workshop for High School Students

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Modern aspects of many subjects (e.g., computer science and some aspects of medical science) are now taught in many high schools, but the plant sciences are often given short shrift. A collaboration was therefore established with a high school biology program in which pilot workshops could be developed to enable advanced students to gain insights into modern plant science techniques. A successful example is the workshop on plant biotechnology presented in this report. This workshop is simple and flexible, taking into account that most high school biology laboratories and classrooms are not set up for sophisticated plant science/biotechnology projects. It is suitable for from 10 to 30 students, depending upon space and facilities available. Students work in pairs or trios, and learn simple disinfection and transfer techniques for micropropagation and potential subsequent transformation treatments. Students gain insights into: sterile technique and hygiene; plant hormones and their physiological effects; plant cell, tissue and organ culture; the influence of environmental factors on response of cells and tissues cultured *in vitro*; and an understanding of the phenomenon of organogenesis and resulting plant growth and development. This workshop has been tested on several classes of students and following analysis, several refinements were included in subsequent iterations. Results of the students' experiments have been positive and instructive, with student learning outcomes above expectations. Further details of the workshop techniques and approach will be presented.

Redesigning the Master Plan for the South Carolina Botanical Garden

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In 1997 the South Carolina Botanical Garden determined the need to reevaluate and update the 1989 Botanical Garden Master Plan. The original comprehensive plan presented recommendations for the long-term development of the site and the facilities of the garden. Significant changes and new programs have arisen since the 1989 Master Plan was completed. Because of the new direction of programs such as the South Carolina Heritage Corridor, Southern Living Home, Conservatory and Outdoor Sculpture Program, it was necessary to develop an updated design strategy to incorporate these future plans into the South Carolina Botanical Garden. Programmatically, the idea of the South Carolina Botanical Garden is to find solace in the garden, to find a retreat from the pressures of everyday life and create a somewhat idyllic world while setting an environment for cultural and botanical conservation. The goal was allowing visitors to move throughout the garden without endangering the existing and established ornamental and native flora as well as educating its visitors. It is on this framework that the Botanical Garden Master Plan is based. The design methodology used in the development of the master plan began with staff meetings, research and site analysis. Design concepts, circulation alternatives and final design choices evolved out of subsequent staff meetings and design reviews. A booklet was also published for future development and fund raising. My presentation will outline the goals, methodology, design decisions and concepts that shaped the final master plan for the South Carolina Botanical Garden.

344

Human Stress Recovery during Exposure to Geranium Visual Stimuli

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Evaluating human psychophysiological responses to plant visual stimuli provides a clearer understanding of factors within plant environments that enhance or maximize recovery from stress. Advances in physiological monitoring technology allow continuous recording and more-refined data collection of human responses to environmental stimuli. The objective of this study was to compare effects on stress recovery by exposures to geranium visual stimuli following an induced stressor, by measuring changes in physiological indicators and emotional states. One-hundred-fifty college students were randomly assigned to one of three treatment groups: red-flowering geraniums, non-flowering geraniums, or no geraniums. Each student viewed a 10-min film of a stressful human situation following a 5-min baseline, then was exposed to an assigned treatment setting during a 5-min recovery period. Continuous physiological measurements were taken of brainwave activities (EEG), skin conductance (EDR), and finger skin temperature. Self-rating scores of subjects' feelings were taken using the Zuckerman Inventory of Personal Reactions. Comparisons among treatment groups will be discussed based on gender and other demographic factors.

345

Relation of Nightshades (Solanaceae) to Arthritis

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Diet appears to be a factor in the etiology of arthritis based on surveys of more than 1400 volunteers during a 25-year period. Plants in the drug family, Solanaceae (nightshades) are an important causative factor in arthritis in sensitive people. This family includes potato (*Solanum tuberosum* L.), tomato (*Lycopersicon esculentum* L.), eggplant (*Solanum melongena* L.), tobacco (*Nicotiana tabacum* L.), and peppers (*Capsicum* sp.) of all kinds, except black pepper (family, Piperaceae). A buildup of cholinesterase-inhibiting glycoalkaloids and steroids from consumption and/or use (tobacco) of the nightshades and from other sources such as caffeine and some pesticides (organophosphates and carbamates) may cause inflammation, muscle spasms, pain, and stiffness. Osteoarthritis appears to be a result of long-term consumption and/or use of the Solanaceae, which contain naturally the active metabolite vitamin D₃, which in excess causes crippling and early disability (as seen in livestock). Rigid omission of Solanaceae, with other minor diet adjustments, has resulted in positive to marked improvement in arthritis and general health.

34 ORAL SESSION 3 (Abstr. 346–352)

Woody Ornamentals/Landscape/Turf— Biotechnology

346

Identification of *Tsuga* Species Hybrids Using Molecular Markers

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In both urban and rural areas, landscape and forest settings, the eastern hemlocks (*Tsuga canadensis* and *T. caroliniana*) are suffering major damage and mortality from the hemlock woolly adelgid (*Adelges tsugae*). Research efforts at the U.S. National Arboretum are focusing on the development of resistant hybrids by crossing the East coast native species with the Asian species *T. chinensis*, *T. diversifolia*, and *T. seiboldii*, which are reported to be more tolerant to damage by the woolly adelgid. More than 2000 seedlings have resulted from these crosses and controls. However, positive identification of these putative hybrids cannot easily be made based on visual inspections due to variation in morphological traits. We are using molecular markers, including RAPD-PCR and Sequence Characterized Amplified Regions (SCARs) to screen putative hybrids. Our data indicate that RAPD bands are useful to analyze the variation within a particular cross, but are of limited use in identifying hybrids. The development of SCARs enables fast and accurate identification of hybrids using only three to four leaves from a seedling. The production of hybrids among these five species will generate novel combinations of genes for studying adaptability, pest resistance, and horticultural attributes, as well as broaden the genetic base of cultivated hemlocks.

347

Preliminary Investigation on Discrimination and Genetic Diversity of *Cephalotaxus* Taxa Using AFLP Markers

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Cephalotaxus species and cultivars have become popular because of their sun and shade tolerance, resistance to deer browsing, disease and insect tolerance, and cold and heat adaptability. Unfortunately, the nomenclature and classification in the literature and nursery trade are confusing due to their extreme similarity in morphology. To address this problem, a preliminary investigation utilizing the AFLP technique was applied to taxon discrimination and genetic difference among 90 *Cephalotaxus* accessions. A total of 403 useful markers between 75- and 500-bp fragment sizes was generated from three primer-pair combinations. The clustering results with reference to morphological characteristics showed that 79 accessions out of 90 can be classified as three species, *C. oliveri* Mast., *C. fortunei* Hook., and *C. harringtonia* (Forbes) Koch., and one hybrid species, *C. x sinensis*; four varieties, *C. fortunei* var. *alpina*, *C. harringtonia* var. *koreana*, *C. harringtonia* var. *nana*, and *C. harringtonia* var. *wilsoniana*; and eight cultivars. Suggested names are provided for mislabeled or misidentified taxa. The *Cephalotaxus* AFLP data serve not only as a guide to growers for the identification and genetic differences of a taxon, but also as a model to establish a "cultivar library" against which later introductions or problematic collections can be cross-referenced.

348

Genetic Relationships among Cultivated Species of *Rhododendron* L. Section *Pentanthera* G. Don Based on DNA Sequence Variation of the Internal Transcribed Spacer (ITS) Region

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Rhododendron section *Pentanthera* has traditionally been viewed as a group of closely related species due to the relative lack of distinctive morphological characteristics separating species and numerous reports in the literature of artificial

and natural fertile hybrids that produce fertile progeny. Significant variation within species has created difficulties in efforts to assemble these taxa into well-defined groups. Genetic relationships among cultivated specimens of the 15 currently recognized species in *Rhododendron* section *Pentanthera* were derived from sequence comparisons of the internal transcribed spacer (ITS) region. Sequences of the entire ITS region including ITS1, ITS2, and the 5.8S subunit were generated by direct sequencing of polymerase chain reaction (PCR) amplified fragments. *Rhododendron vaseyi* A. Gray, *Rhododendron* section *Rhodora* (L.) G. Don was used as an outgroup. Aligned sequences of the 16 taxa resulted in 690 characters. A distance matrix of sequence divergence was calculated using Kimura's two parameter model. A bootstrap analysis was performed and a phenogram was constructed using MEGA. A phenetic assay rather than a phylogenetic analysis was performed because the ITS region contained only eight (1.16%) phylogenetically informative sites. The entire ITS region contained 41 variable sites (5.94%). Five species had identical ITS sequences. Seven additional species differed only by one or two base pair substitutions and/or the addition or deletion of one or two base pairs. *R. luteum* Sweet, *R. occidentale* A. Gray, *R. molle* (Blume) G. Don, and the outgroup, *R. vaseyi* had noticeable variation (base substitutions, additions, and deletions) compared to the other species. Divergence values among the taxa were extremely low, ranging from 0.00% to 3.51%. This molecular data, and previous hybridization studies, do not support the accepted taxonomic treatment of the section.

349

In Vitro Establishment of Powdery Mildew (*Microsphaera pulchra*) on Microshoots of Flowering Dogwood

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Microshoot and callus cultures of *Cornus florida* (flowering dogwood), which were grown on woody plant medium amended with BA, were inoculated with *Microsphaera pulchra* (an obligate plant parasite) by gently shaking infected leaves bearing numerous conidia over the tissue. Culture dishes were sealed with parafilm and incubated at 24 °C with 25 mol·m⁻²·s⁻¹ provided by cool fluorescent bulbs for 15 h. Cultures were examined with a dissecting scope every 24 h and cultures transferred when contaminating fungi were present. Specimens were prepared light microscopy and SEM. The fungus infected individual callus cells, but did not sporulate. In contrast, powdery mildew was well-established (both primary and secondary hyphae) in 70% of the microshoot cultures after 6 days and sporulated on 20% by 7 to 8 days. The cellular relationship between host and pathogen in vitro was similar to that found in greenhouse-grown plants. This technique has possible applications in maintaining fungal culture collections and studying host-pathogen relationships under more stringently controlled conditions.

350

In Vitro Screening of Azalea for Resistance to Azalea Lace Bug

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Azalea lace bug (*Stephanitis pyrioides*) is the most serious pest on azalea. Results of laboratory bioassays and field evaluations of 17 deciduous azalea taxa have identified three resistant taxa: *R. canescens*, *R. periclymenoides*, and *R. prunifolium*. Highly susceptible taxa are 'Buttercup', 'My Mary', *R. oblongifolium*, and the evergreen cultivar 'Delaware Valley White'. To determine whether in vitro techniques would have potential value in screening or selecting for resistance, or for the identification of morphological or chemical factors related to resistance, an in-vitro screening assay was developed. In-vitro shoot proliferation was obtained using the medium and procedures of Economou and Read (1984). Shoots used in the bioassays were grown in culture tubes. Two assays were developed: one for nymphs and one for adult lace bugs. To assay for resistance to nymphs, 'Delaware Valley White' leaves containing lace bug eggs were disinfested with 70% alcohol and 20% commercial bleach, and incubated in sterile petri plates with moistened filter paper until the nymphs hatched. Five nymphs were placed in each culture tube, and cultures were incubated for about 2 weeks, or until adults were observed. To assay for resistance to adults, five female lace bugs were placed in each culture tube and allowed to feed for 5 days. Data collected on survival and leaf damage was generally supportive of laboratory bioassays and field results. Adult lace bugs had a low rate of survival on resistant taxa. Survival of nymphs was somewhat reduced on resistant taxa.

351

Ancymidol Increases In Vitro Multiplication Rate of *Hosta* in Liquid Media

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The main and interactive effects of plant growth regulators were assayed to optimize multiplication rate for *Hosta* in liquid media. Two varieties of *Hosta* were run through three 4-week subculture cycles in shake flasks. When *Hosta* 'Blue Cadet' was grown on three concentrations of cytokinin (1, 2.25, and 5 µM BA), three concentrations of auxin (0.1, 1.0, and 10 µM IAA), and four concentrations of an anti-gibberellin growth regulator (0.0, 0.1, 0.32, and 1.0 µM ancymidol), multiplication rates improved markedly during the first two subculture cycles in liquid (1.7 and 3.6x, respectively) before stabilizing at third subculture. BA and ancymidol both increased multiplication rate. IAA interacted antagonistically with BA. An optimal multiplication medium with 2.25 µM BA, 1.0 µM IAA, and 1.0 µM ancymidol, provided a high rate of multiplication with well-defined shoot morphology and minimal root growth. Media consisting of 1.0 µM BA, 10.0 µM IAA, and 0.32 µM ancymidol was effective in producing leafy plantlets, with root initials, ready for transfer to mist bed acclimatization. When *Hosta* 'Stillette' was grown on concentrations of cytokinin (1, 2.25, and 5 µM BA), auxin (0.1, 1.0, and 10 µM IAA) and ancymidol (0.0, 1.0, and 3.2 µM), multiplication rates improved markedly during the first two subculture cycles in liquid (1.9 and 2.4x, respectively) before stabilizing at third subculture. Ancymidol increased multiplication rate at either level: the interactive effect with BA showed highest multiplication rates at lowest BA levels in the presence of ancymidol. Lower BA concentrations promoted better culture morphology and lesser BA induced root inhibition.

352

Eliminating Thrips in Microshoot Cultures

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Two insecticides, acephate or azadirachtin, were added to tissue culture media to determine their effectiveness in controlling onion thrips (*Thrips tabaci* Lindeman.) and to determine if these insecticides could damage the plant shoot cultures. To test for insecticide phytotoxicity, microshoots from European birch (*Betula pendula*), American elm (*Ulmus americana*), 'Pink Arola' chrysanthemum (*Dendranthema grandiflora*), 'America' rhododendron (*Rhododendron catawbiense*), 'Golden Emblem' rose (*Rosa hybrida*), and 'Gala' apple (*Malus domestica*) were placed in 130-ml baby food jars containing 25 ml of medium supplemented with 6.5, 13, or 26 mg/l Orthene[®] (contained acephate) or 0.55, 1.1, or 2.2 ml/l Azatin[®] (contained azadirachtin). Control jars lacked insecticide. To test for thrips control, 13 mg/l Orthene[®] or 0.55 ml/l Azatin[®] was added to Murashige and Skoog medium, and 10 thrips were placed on 'Gala' apple microshoots in each jar. Jars were sealed with plastic wrap. In both studies, microshoot dry weight and heights were determined. In the second study, the total number of thrips per jar was also determined 3 weeks after inoculation. Microshoots on Orthene[®]-treated media lacked phytotoxicity symptoms, regardless of the concentration used. In contrast, Azatin[®] hindered plant growth, decreasing shoot height or dry weight by up to 85% depending on the species. Both insecticides prevented thrips populations from increasing, since less than 10 thrips were found in jars with insecticide-treated medium. Control jars, however, contained an average of almost 70 thrips per jar. This study demonstrated that both Orthene[®] and Azatin[®] were effective for eradicating thrips from plant tissue cultures, but Orthene[®] should probably be used because Azatin[®] was phytotoxic to all species tested.

35 ORAL SESSION 4 (Abstr. 353–359) Technology Applications in Extension Horticulture

353

Factsheet Database: A Comprehensive Collection of Publications for the United States and Canada

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A full-text searchable database is available through the Internet that captures factsheets, bulletins, and other Extension publications related to horticultural and agronomic crop production and culture. Electronically accessible information from Extension in 50 different colleges and universities across the United States and Canada was indexed by a robot software program and provides clients with access to over 14,000 publications. This database represents the most concentrated source of plant-related information available for answering questions, developing outreach programs, or assisting individuals to learn about plants. Information can be searched globally or limited to regional searches, e.g., Midwest, Northeast, Southeast, Southwest, West (including Hawaii), North Central, and Alaska, plus Canada. The address for the web site is: www.hcs.ohio-state.edu/factsheet.html.

354

The Development of Web-based Searchable Databases for the Green Industry

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Despite the explosion of resources on the World Wide Web (Web) over the past 3 years, there are still relatively few sites that provide easily accessible diagnostic information on horticultural subjects. For members of the Green industry, (i.e., greenhouse and nursery growers, landscape contractors, and scouting professionals) there is a real need for Web-based resources that provide detailed information on specific subjects that can be accessed at any time. The creation of diagnostic pictorial databases with self-learning capabilities (e.g., hyperlinked glossaries to technical terms) that are carefully designed to include expert diagnostic advice, with methods of control specifically keyed to the diagnosis, will be a powerful method to educate and inform users from the industry and in the classroom. One such database, called *Tospovirus*, has been developed by the authors that can be searched by host species and tissue type, since this important virus has a wide host range and symptomatology. Since at the present time the only control measure for this virus is eradication, growers can use this database to immediately identify suspicious plants in the greenhouse or nursery before further infection occurs. The development process of this database will be outlined to give the audience an idea of the decision-making process involved in this rapidly evolving method of information transfer.

355

Creation and Maintenance of a Horticultural Education Web Site by an Extension Specialist Without HTML Programming Skills

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Informational web sites on the World Wide Web (WWW) are another means for extension educators to transfer information to a clientele and provide access to new audiences. One of the problems inherent in the utilization of this new technology is the amount of effort required by those involved in order to become proficient enough to accomplish their goal of sharing information through a web site. Through the use of a HTML editor and the assistance from staff knowledgeable about the WWW, a web site on a main campus server was created by untrained off-campus personnel at a remote site to provide information on commercial vegetable production. Planning of the web site included targeting potential audiences, determining what information would be shared from the site, and building a team of extension and research personnel that would provide information and act as reviewers for web publications. Assistance in the form of graphics and general know-how were supplied by departmental specialists. After development, the web site was maintained and refined on a regular basis through the utilization of the HTML editor and a web file transfer program.

356

Aggie Horticulture on Disk

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The Aggie Horticulture Web site was written to CD-ROM using readily available, inexpensive equipment, supplies, and software. The CD-ROM version is

accessed using the "load from file" option of the commonly used Web browsers and is cross-platform compatible. Writing to CD does not allow "server-side" functions such as cgi-based searching and forms posting and the content of the site is fixed at the time the CD is written. However, in situations where Web connectivity is limited in speed or where phone connections are unavailable, the CD represents a low-cost alternative for accessing large volumes of information. Aggie Horticulture on Disk will be demonstrated, and several precautions to be followed to ensure an error-free transition from Web site to CD will be described.

357

Extension Program Delivery for Greenhouse Growers Using Compressed Video Technology

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There is a need for educational programming for greenhouse growers on effective uses of biorational pesticides and biological controls of insect and mite pests, diseases, and alternatives to herbicide sprays in confined areas; however, in many states, travel for specialists for programming and workshops is becoming prohibitive. A series of programs outlining Best Management Practices (BMP) for the greenhouse industry outlining techniques and practices reducing pesticide use were conducted at multiple sites in Colorado simultaneously using interactive compressed video technology. This conferencing technology is gaining wide acceptance in many venues and provides an opportunity for wider participation of clientele without travel. Participants in the programs reported in post-session evaluations that they did miss the personal interaction with the speakers, but did acknowledge that not having to drive 5 hours to attend a seminar was quite beneficial.

358

Creation and Use of a Video as an Educational Tool

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Two Smith-Lever IPM Grants provided the funds to develop and disseminate information in an educational video about Walnut Husk Fly (WHF). The video was produced as a new way of conveying information about the techniques available to control WHF. Helping clientele implement new information on treatment timing was also a goal. The video was shown to 1154 clientele at 16 educational meetings. Fifteen regional trials were conducted across California to demonstrate the techniques illustrated in the video. Three-hundred-and-twenty-four clientele took a WHF quiz before and after viewing the video. Test results improved by 83%. A questionnaire indicated the video was a better format than a slide presentation for learning new information. Clientele particularly liked the review section at the end of the video. Seventy-five clientele participating in a postharvest telephone interview indicated that the information in the video helped them control WHF. Sixty-two percent used the new techniques described and 65% felt that the information presented improved their treatment timing. As a result of using information presented in the video, both the average number of treatments and insect damage was reduced. This 2-year project trained clientele representing over 40,000 acres of walnuts. Each Cooperative Extension office and IPM Advisor was given a copy of the video. In addition, over 70 copies of the video have been sold, several to pesticide companies for training of their pest control advisors.

359

Oklahoma Gardening—Extension Horticulture Education Through Television

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In an era of shrinking Extension resources the question of how to reach large audiences with horticulture information is a pressing concern. Now in its 23rd year, Oklahoma Gardening is an example of spreading Extension information to large audiences through television. Oklahoma Gardening is produced cooperatively by the Oklahoma Cooperative Extension Service, the Dept. of Horticulture and Landscape Architecture, and the Dept. of Ag. Education, Communication, 4-H and Youth Development. The show offers traditional how-to information about gardening, lawn care, and landscaping, as well as up-to-date university research on horticulture. Extension specialists from other disciplines such as entomology, plant pathology, human environmental sciences, and soils frequently contribute

to the show fostering cooperation between these programs. Weekly, Oklahoma Gardening reaches more than 175,000 viewers in Oklahoma and surrounding states. County Extension Educators are kept informed of programming and provided with support materials for each weekly show. They are also encouraged to provide input as to content and needs in their particular area of the state. In addition, consumer horticulture programming and show content are closely tied and the show serves as a bulletin board for horticulture related events coordinated by the extension service.

36 ORAL SESSION 5 (Abstr. 360–366) Perennials & Poinsettias—Floriculture

360

The Influence of Light and Temperature on Flowering and Growth of *Angelonia angustifolia* Benth.

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Angelonia Humb. & Bonpl. (*Angelonia*), Scrophulariaceae, consists of about 30 species and has potential in amenity horticulture and as a pot plant. Selections of *A. angustifolia* Benth. and hybrids occur in several flower colors and have been evaluated for amenity purposes. Selected taxa were grown in different photoperiods (8-h, 16-h and combinations), light intensity, and temperature regimes (10–30 °C) to determine optimum environments for flowering and growth. Preliminary studies indicate that plants are only slightly responsive to photoperiod. Plants reached visible bud stage 4 to 10 days earlier in long-day treatments, but the time from visible bud to flower was unaffected. Raceme length was longer in LD plants. Plants flowered more rapidly and produced more flowers in high light and warm temperatures. Performance of plants in a landscape situation will also be discussed.

361

Vernalization Accelerates Flowering of *Lysimachia clethroides* Duby

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The effect of vernalization method and duration on off-season cut flower production of *Lysimachia clethroides* Duby was examined. Rhizomes harvested in October were cooled for 0, 4, 6, 8, 10 or 12 weeks at 4 ± 1 °C in crates with unmilled sphagnum peat or in 3.75-L pots with potting media prior to forcing in a warm greenhouse. After 6 or more weeks of cooling, shoots emerged from crate-cooled rhizomes in higher percentages than from pot-cooled rhizomes. However, only the duration of cooling, not the method, affected the rate of shoot emergence, visible bud formation and anthesis of the first bud in the raceme. As cooling increased from 0 to 12 weeks, the greenhouse days required for shoot emergence, visible bud formation and anthesis decreased linearly. The number of flowering flushes and flowering stems varied quadratically with cooling duration, and the highest yields occurred when rhizomes received between 4 and 10 weeks of cooling. As the number of successive flowering flushes increased, the stem length increased linearly while the stem diameter decreased linearly. High numbers of flowers were produced rapidly after 10 weeks of cooling.

362

Cold Treatments Alter the Photoperiodic Flowering Response of Some Herbaceous Perennial Species

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Many species of herbaceous perennials either require a cold treatment for flowering or exhibit enhanced and more desirable flowering characteristics following a cold period. For some species, the photoperiodic induction of flowering can change following cold treatments, the parameters generally becoming less strict as plants receive longer durations of cold until a saturation duration is reached. To quantify the minimum and saturation durations of cold for flowering under short days (SD) and long days (LD), five species were selected and cooled for 0, 3, 6, 9, 12, or 15 weeks at 5 °C, then forced at 20 °C under 9-h photoperiods without (SD) or with a 4-h night interruption (LD). The effects of cold and photoperiod

on flowering varied by species. For example, under SD, 0%, 80%, or 100% of *Leucanthemum xsuperbum* 'Snowcap' flowered after 0, 3, or ≥ 6 weeks at 5 °C, respectively, and time to flower decreased from 103 to 57 days as the duration of cold increased from 3 to 12 weeks. 'Snowcap' cooled for ≥ 3 weeks, then forced under LD, flowered completely in 45 to 55 days. Flowering percentage of *Lavandula angustifolia* 'Hidcote' reached 100 under LD or SD only when plants were cooled for ≥ 6 or 15 weeks, respectively. Under LD, flowering percentage of *Astilbe chinensis pumila* progressively increased from 0 to 100 as cold treatment increased from 0 to 15 weeks; flowering percentage under SD was low regardless of cold treatment. Additional species and flowering characteristics will be discussed.

363

Lime and Lavender: The Ornamental Sweetpotato Wins Respect in the Landscape

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Impressive its first several seasons on the market, the ornamental sweetpotato (*Ipomoea batatas*) provides nearly carefree cascades of fade-proof yellow-green, purple, or variegated foliage that looks equally good on banks, in beds, or in hanging baskets. A foil for both bright and subdued flowering plants, such as abelmoschus or petunias, ornamental sweetpotatoes add both dramatic color contrasts and dimension to plantings of all kinds. As demonstrated at the 1996 Summer Olympics, large containers filled with ornamental sweetpotatoes, such as 'Margarite' and 'Blackie', and the muted greys, greens, purples, and golds of artemesia, fountain grass, and lantana create an unusual and dependable planting that holds up to heat and humidity and is generally pest-free. Cultivation requirements are minimal. *Ipomoea* performs best in full sun with good drainage and regular garden soil. However, it will tolerate poor soil, dry conditions, even semi-shade as well. In spite of its horticultural and aesthetic qualities, *Ipomoea* has still to be utilized fully in home and commercial plantings. As new varieties are introduced and the spectrum of color increases, *Ipomoea* should become a true mainstay of the ornamental industry.

364

Response of Poinsettia Growth and Development to Ratio of Radiant to Thermal Energy

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A concept of ratio of radiant to thermal energy (RRT) has been developed to deal with the interactive effect of light and temperature on plant growth and development. This study further confirms that RRT is a useful parameter for plant growth, development, and quality control. Based on greenhouse experiments conducted with 27 treatment combinations of temperature, light, and plant spacing, a model for poinsettia plant growth and development was constructed using the computer program STELLA II. Results from the model simulation with different levels of daily light integral, temperature, and plant spacing showed that the RRT significantly affects leaf unfolding rate when RRT is lower than 0.025 mol/degree-day per plant. Plant dry weight is highly correlated with RRT; it increases linearly as RRT increases.

365

Quantifying the Effect of Canopy Closure on Poinsettia Stem Elongation

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The rate of poinsettia stem elongation is affected by several factors, including light quality, i.e., specific wavelengths of irradiance. As the plants grow and the canopy closes, the red to far-red ratio is reduced and stem elongation is promoted. The objective of this project was to quantify the effect of canopy closure on the stem elongation rate of pinched 'Freedom' poinsettias. In the first experiment, individual plants received 413, 645, 929, 1264, or 2580 cm² of growing area at the time of pinch. The maximum rate of stem elongation for the five spacing treatments was 2.9, 3.8, 4.3, 5.6, or 7.5 mm/day, respectively. In the second experiment, plants were grown at a "tight" or a "wide" spacing as defined by the percentage of PPF transmission measured between plants. The "wide" spacing treatments allowed 50% PPF transmission, while the "tight" spacing treatment allowed 10% PPF transmission. A constant degree of closure was maintained by weekly adjusting plant spacing based on the PPF transmission measurements. The maximum rate

of stem elongation of the "tight" spacing was 4.6 mm/day compared to 3.1 mm/day for the "wide" spacing treatment.

366

Photoperiod and Temperature Influence on Flower Initiation and Development for *Euphorbia pulcherrima* Grown Under Florida Conditions

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Four poinsettia cultivars were grown in glass greenhouses in Gainesville, Fla., in the Fall 1997 to evaluate differences in floral initiation and subsequent development. Three means of regulating photoperiod were 1) natural days 2) long-day lighting to 6 Oct. and then natural days (lights out) 3) long-day lighting to 6 Oct., and then short-day conditions by black cloth for 15 h (black cloth). At 2-day intervals, sample meristems were collected and examined for initiation of reproductive development. Average minimum and maximum temperatures during the first two weeks of October were 22 and 29 °C, respectively, with an average temperature of 25.3 °C. The overall average temperature was 23.2 °C from planting to anthesis. Differences in anthesis dates among cultivars were primarily due to time to initiation vs. rate of development. Under natural days, 'Lilo' initiated first on 8 Oct. and 'Freedom', 'Peterstar', and 'Success', followed by 6, 8, and 18 days, respectively. Lights out resulted in 'Lilo' initiating 17 Oct., followed by 'Freedom', 'Peterstar', and 'Success' initiating 7, 12, and 15 days later, respectively. Differences between cultivars in time of initiation was reduced under black cloth, where 'Lilo' initiated 14 Oct., followed by 'Freedom' 2 days later, and 'Peterstar' and 'Success' 7 days afterward. Initiation was positively correlated to visible bud and anthesis. First color was positively correlated to initiation and visible bud, with the exception of 'Lilo'. Growth room studies conducted using various high temperatures and photoperiods indicated similar trends.

37 ORAL SESSION 6 (Abstr. 367–374) Undergraduate Education

367

Developing and Implementing a Field Trip Course in Public Gardens

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Public gardens, including public parks, botanical gardens, and arboreta are significant tourism destinations with increasingly popular appeal. In the United States alone, the number of gardens is continuing to rise impressively. Undeniably, there is a need for trained and educated horticulturists who can enter the horticulture industry, specifically in the area of public garden management. At the Univ. of Florida, a new course, ORH 4932, Public Gardens was offered. This course was designed with a field trip emphasis to help students visually understand and appreciate the value and diversity of such gardens. Students taking the course had an opportunity to visit and tour various gardens throughout the state of Florida. At the same time, students learned about the history, management, collections, and importance of such institutions to society. This session will explore the value of student experiences in the learning process, present an overview of how to develop a field trip class, and provide information to other educators interested in offering such a course.

368

Using Extended Field Trips to Enhance the Undergraduate Experience

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While the use of field trips is not new to undergraduate education, tailoring a 3- to 4-day field experience to enhance classroom instruction is challenging, but rewarding, for students, faculty, and alumni. Drawing on alumni in the private and public sectors to serve as guides has added significantly to the experience and has strengthened alumni ties to the department. Problems associated with extended field trips, such as those related to behavior and legal liabilities, can often be avoided by proper scheduling and insurance planning. Funding can be augmented by an industry eager to find qualified graduates.

369

Breaking the Vegetative Cycle of Plant Materials Lectures

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Routine lectures, even in topics as inherently appealing to students as plant materials classes, can become monotonous. Educational games can be effective mechanisms for breaking the classroom routine, stimulating student interaction, and reviewing key concepts in an alternative teaching/learning style. Three plant materials games that can be tailored to apply specifically to regional/local classes were developed based on popular television game shows. Basing the formats on games with which the students are familiar allows minimal time and effort to learn the rules and permits students to immediately participate in the activity. The names of the games are "Plant Pictionary", "Plant Taboo", and "Name That Plant". A brief game of each can be completed within 15 to 20 min. The games were developed using plant morphology, taxonomy, aesthetic characteristics, and/or site requirement terminology introduced for general concepts or specific taxa covered in the course. Based on student evaluations, these activities were well received when periodically inserted into the lecture sessions. Participation and enthusiasm for the activities was greatest during the later half of the semester, likely due to the greater base of knowledge that could be incorporated into the games. The games worked best as group activities, particularly fostering good natured competition among laboratory sections. The general concepts of the games should be transferable to other subject matter areas.

370

IPM—A Problem-based Learning Approach

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The Cal Poly philosophy of "Learn and Understand by Doing" has been integrated with problem-based learning and the use of the latest technology to produce a class that closely simulates real-life pest control situations. Goals of the class, Disease and Pest Control Systems for Ornamental Plants, are to teach students pest monitoring, control and problem solving techniques, the use of resources including the internet and journals, and the use of the latest pest control equipment and application techniques. Students are shown pest situations and then work in groups to diagnose the problem, investigate management strategies, apply control measures, and monitor results. Weekly class presentations inform the class of the various projects and help to teach the class organization and presentation skills. Student evaluations and test performance have demonstrated that students achieve class objectives substantially better with the problem-based learning approach than with the previous lecture-based approach to the class.

371

Service Learning and Environmental Education

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Service learning is a teaching method that enables college students and faculty to learn while identifying and solving community problems. A case study involving the creation of sustainable landscapes for a low-income community in Clemson, S.C., will be used to illustrate the methodology necessary to complete a successful service learning project. Clemson Univ. students from four courses worked towards advancing their knowledge and commitment to environmental stewardship. They enhanced their education in landscape design and implementation through a partnership with the City of Clemson, Habitat for Humanity, the National Wildlife Federation, and others which resulted in the creation of certified backyard habitats for low-income residents.

372

Development of an Undergraduate Curriculum in Landscape Contracting

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Introducing a new curriculum option has led to greater student enrollment, more highly qualified students entering the curriculum, and better relations with and support from an expanding landscape industry. Student skills development, and enthusiasm has been enhanced by contemporary computer facilities, retooled instructional practices, new courses, strong ties to the industry, required internship,

and an active post-graduation placement program. Justification for this option as well as specific details will be discussed.

373

Comparisons of Field-dependent and -independent Student Learning Preferences in an Ornamental Horticulture Class with an Emphasis on Computer-assisted Instruction

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Learning Preference differences and similarities of field-dependent/-independent students were investigated with an emphasis on the usage of a computer-assisted instruction (CAI) program designed for a woody plant identification class. Qualitative interviews further investigated each participant's cognitive learning style after administration of the Group Embedded Figures Test instrument. The findings were congruent with the theory of field dependency. In addition, results indicated that field independent students felt that using CAI was beneficial, but may prove to be more advantageous with provided structure. In contrast, field-dependent students did not feel there was any benefit in using a CAI program, but, with provided structure, benefits may occur. However, both field-dependent/-independent students would prefer a greater usage of visuals in this CAI program.

374

Analysis of Demographics and Factors Influencing Student Choice of Major at Five Universities

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In recent years horticulture programs at universities across the United States have experienced a decline in student numbers. Researchers at the Univ. of Florida and Texas A&M Univ. have developed a survey to gain insight into the influences on undergraduate students who major in horticulture. Five universities participated in the survey of undergraduate horticulture programs, these include the Univ. of Florida, Texas A&M Univ., Oklahoma State Univ., Univ. of Tennessee, and Kansas State Univ. Approximately 600 surveys were sent to the schools during the 1997 fall semester. The questionnaires were completed by horticulture majors and non-majors taking classes in the horticulture departments. The survey consisted of two main sections. The first section examined student demographic information, high school history, university history and horticulture background and was completed by all students. Only horticulture majors completed the second section, which examined factors influencing choice of horticulture as a major. Results examine fundamental predictors in promoting student interest in horticulture, demographic variables that may influence student choice of major, and student satisfaction and attitude toward current collegiate horticulture programs. Findings from this study will provide insight into the status of post-secondary horticulture education and assist in identifying methods to increase student enrollment in horticulture programs across the country.

47 ORAL SESSION 7 (Abstr. 375–381) Small Fruit & Viticulture—Crop Production/Physiology

375

Using Chlorophyll Fluorescence (Fv/Fm) as an Objective, Sensitive, and Efficient Method to Determine Cane Tissue Hardiness of Grapevines

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Determining hardiness levels of plant tissues is a prerequisite for cold hardiness research. LT₅₀ determined by browning or regrowth tests is reliable and the most widely used means for assessing woody vegetative tissue viability. It is, however, time consuming and subjective. Although chlorophyll fluorescence (Fv/Fm) has been recently proposed to measure tissue injury for leaf and bud tissues, there are no reports on use for assessing viability of freezing-stressed woody tissues. We investigated the Fv/Fm changes of 1- and 2-year-old canes of

Concord grapevines during the cold acclimation and compared these with browning and regrowth tests. The data showed that: 1) There were statistically significant, positive relationships between Fv/Fm changes and freezing temperature treatment that caused tissue injury. The best fit curvilinear equations were obtained; 2) The time of measuring chlorophyll fluorescence post-stress was important. Immediate assessment was not as precise in separating cold hardiness difference as when the tissue was measured 1 week later (at the time of browning test evaluation) or 4 weeks later (at the time of regrowth test evaluation). Assessment 20–26 h post-stress was equivalent to the 1-week or 4-week assessment. These data suggest that chlorophyll fluorescence (Fv/Fm) is a useful practical tool for assessing vegetative tissue viability. Importantly, it is rapid, simple, and objective.

376

Influence of Mechanical Shoot Positioning on Fruit Exposure, Yield, and Fruit Quality of 'Concord' Grapevines

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'Concord' grapes grown in cool climates often encounter fruit maturity problems relative to desired processor standards. Exposure of grape clusters to sunlight may promote fruit maturity. A mechanical device for reorienting shoots on grapevines to increase fruit exposure was evaluated on 'Concord' grapevines, which had been managed with Hudson River Umbrella training and balance-pruned to retain 44 nodes per kilogram of cane prunings. Three times of positioning and combinations of these times were evaluated for a 3-year period. Positioning consistently increased fruit exposure. Increases in fruit soluble solids were dependent upon the year and the time of positioning. Excessive reduction of leaf area resulting from some treatments is suggested as a factor depressing fruit soluble solids. The value of this approach to mechanical shoot positioning for enhancing fruit maturity depends upon the seasonal influence on grapevine canopy development. When excessive canopy develops, mechanical shoot positioning is likely to enhance fruit maturity.

377

Quantifying the Chilling Status of Grapevines and the Response to Dormancy-breaking Chemicals in the Coachella Valley of California

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A method to quantify the chilling status of grapevines grown in a desert region, in order to better predict vine response to dormancy-breaking chemicals, was examined. Chilling status was determined by calculating the ratio between exposure to chilling temperatures (hours $\leq 7^{\circ}\text{C}$) and chill-negating temperatures (hours $\geq 20^{\circ}\text{C}$) from the beginning of the dormant period (1 Nov.) to the date of pruning (mid-December). A 6-year field study (1991 to 1996) compared the budbreak of untreated vines, and vines treated with H₂CN₂ (2% v/v) immediately after pruning, exposed to a range of chill:chill negation ratios resulting from yearly variations in environmental conditions. Budbreak was delayed, and total budbreak reduced, when the chill:chill negation ratio was <0.5 . In contrast, rapid and complete budbreak was observed when the chill:chill negation ratio was >2 . The standard dormancy-breaking treatment in this region, 2% (v/v) H₂CN₂, provided acceptable budbreak when the chill:chill negation ratio was near 1. Higher concentrations of H₂CN₂ were needed when the chill:chill negation ratio fell below 1, while H₂CN₂ could be reduced when the chill:chill negation ratio was 2 or more.

378

Influence of Light on Fruit Set of French Hybrid Grapes

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Four French-American hybrid grape cultivars grown in a greenhouse were subjected to 5 days of 80% shade at four different times around bloom. Fruit set of 'Seyval' was reduced by shade imposed before, during, or immediately after bloom. 'Vidal' and 'Chambourcin' were less sensitive, with fruit set reduced only by shade at bloom. Shade had little effect on fruit set of 'DeChaunac'. In a second study, 'Chambourcin' vines were exposed to ambient, ambient plus supplemental lights, and 30%, 50%, or 80% shade for 5 weeks beginning just prior to bloom. Fruit set was positively related to light intensity. At harvest, soluble solids, pH, and

hue angle had a negative linear relationship to light level. Fruit color developed earliest and most rapidly with the reduced light treatments applied at bloom. Cluster weight was positively related to light intensity.

379

Influence of Pruning and Irrigation on Root Longevity of 'Concord' Vines

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Improved cultural practices in grape require a better understanding of root growth and physiology. Seasonal root dynamics were examined in mature 'Concord' vines with balanced or minimal-pruning, and with or without supplemental irrigation in Fredonia, N.Y. Fine roots were continuously produced during the growing season starting in mid-June around time of bloom. Roots began to die in September at veraison. Minimal-pruned vines produced more roots than balanced-pruned vines, with the minimal-pruned/unirrigated vines producing the most roots. Irrigation and pruning delayed fine root production at the beginning of the growing season. Peak fine root flush was 16 June to 21 July 1997 for the minimal-pruned/unirrigated treatment, while peak flush was 7 July to 2 Sept. 1997 for balanced-pruned/irrigated treatment. In minimal-pruned vines, many roots were observed down to depths of 120 cm. In contrast, balanced-pruned vines had very few fine roots deeper than 40 cm. From initial observations, median lifespan of fine roots was 5 to 9.5 weeks, depending on treatment and depth in soil. Fine roots lived longer in the top 15-cm than in the 16- to 30-cm layer of soil in all treatments. Both minimal pruning and irrigation increased root lifespan. Fine roots had the shortest lifespan in the balanced-pruned/unirrigated treatment and the longest lifespan in the minimal-pruned/irrigated treatment.

380

Fumigation of 'Flame Seedless' Grape With *E-2-Hexenal* Reduces Mold during Long-term Cold Storage

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'Flame Seedless' grapes were fumigated with vapor of *E-2-hexenal* to determine if the compound could reduce mold during long-term cold storage. The compound (100 or 200 μ L) was placed in 1-L low-density film-wrapped clamshell containers with 150 g of fruit, and the packages were stored at 2 °C. The packages were vented at 4 and 8 weeks to prevent excessive oxygen depletion or carbon dioxide accumulation. At 2, 4, and 8 weeks, a subset of packages were removed from cold storage and transferred to 20 °C following removal of the over-wrapped film and remaining chemical from the containers. Mold development and quality changes were assessed for the subsequent 13 days. The vapor phase concentration of *E-2-hexenal* was at a maximum within 1 day and declined to less than 25% of initial levels by 2 weeks of 2 °C storage. The higher volume of chemical resulted in a higher headspace concentration, and the fruit removed a proportion of the chemical from the headspace. There were no significant effects of *E-2-hexenal* on fruit weight loss, firmness, or total soluble solids concentration. After 2 weeks of cold storage, fumigation with *E-2-hexenal* had no effect on incidence of mold. However, after 4 and 8 weeks of cold storage, mold was significantly reduced by both rates of *E-2-hexenal*.

381

Preliminary Report on the Apparent Control of Pierce's Disease (*Xylella fastidiosa*) with Admire (Imidacloprid) Insecticide

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Pierce's Disease is the major limiting factor in the production of European and American bunch grapes in the Coastal Plain and Lower Piedmont of the Southeastern United States. Pierce's Disease is also a significant problem in some areas of California. The disease has been impossible to control with insecticide sprays up to this point, because the leaf hopper vectors are xylem feeders and have minimal plant/insecticide contact. Admire was cleared for use on grapes 3 years ago, and an experiment was started near Tifton, Ga. Cultivars of European

and American bunch grapes in this experiment include 'Flame Seedless', 'J. Riesling', 'Cabernet Franc', 'Reliance', 'Mars' and 'Canadice'. Experimental design is a randomized complete block with two replications and six vines per replication and treatment for a total of 72 vines in the experiment. Treatments are untreated control and vines treated with Admire (3.26 g/vine per application) in an aqueous solution of 1 to 2 L applied as a basal drench. Vines were planted in Mar. 1996 and applications of Admire have been applied in the early spring and mid summer of each year. Apparent Pierce's Disease symptoms became evident on some of the control vines in mid-summer 1997. By Fall 1997, some of the control vines were dead. This trend has continued in Spring 1998. Some vines treated with Admire show slight Pierce's Disease symptoms, but rate of disease development is much slower than in the control vines. Based on company research with virus transmission on other crops, even better results can be expected when large blocks are treated with Admire. Current results on this experiment will be presented. Larger scale experiments are underway as well as experiments to determine the effect of Admire on the development of phony peach disease and plum leaf scald disease.

48 ORAL SESSION 8 (Abstr. 382–389) Woody Ornamentals/Landscape/Turf— Crop Physiology

382

Temperature Response of Whole-plant CO₂ Exchange Rates of Magnolia (*Magnolia grandiflora* L.)

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Photosynthesis and respiration temperature-response curves are useful in predicting the ability of plants to perform under different environmental conditions. Whole crop CO₂ exchange of two groups of magnolia 'Greenback' plants was measured over a 26 °C temperature range. Net photosynthesis (P_{net}) increased from 2 to 17% C and decreased again at higher temperatures. The Q_{10} for P_{net} decreased from ≈ 4 at 6 °C to 0.5 at 24 °C. The decrease in P_{net} at temperatures over 17 °C was caused by a rapid increase in dark respiration (R_{dark}) with increasing temperature. The Q_{10} for R_{dark} was estimated by fitting an exponential curve to data, resulting in a temperature-independent Q_{10} of 2.8. Gross photosynthesis (P_{gross}), estimated as the sum of R_{dark} and P_{net} , increased over the entire temperature range (up to 25 °C). The Q_{10} for P_{gross} decreased with increasing temperature, but remained higher than 1. The data suggest that high respiration rates may be the limiting factor for growth of magnolia exposed to high temperatures, since it may result in a net carbon loss from the plants. At temperatures below 5 °C, both P_{net} and R_{dark} become low and the net CO₂ exchange of the plants would be expected to be minimal.

383

Heat Tolerance of Selected Provenances of Atlantic White Cedar

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Uniform seedlings of six provenances (Escambia Co., Ala.; Santa Rosa Co., Fla.; Wayne Co., N.C.; Burlington Co., N.J.; New London Co., Conn.; and Barnstable Co., Mass.) of Atlantic white cedar [*Chamaecyparis thyoides* (L.) B. S. P.], were transplanted in Apr. 1997 into 0.95-L plastic containers with a medium of 1 peat : 1 perlite : 1 vermiculite (v/v). Plants were acclimatized at 26/22 °C under a 16-hr photoperiod for 2 weeks before treatment initiation. Fourteen seedlings per provenance were then transferred to each of five growth chambers maintained at 16/8 hr thermoperiods of 22/18 °C, 26/22 °C, 30/26 °C, 34/30 °C, or 38/34 °C with a 16-hr photoperiod of 550–600 μ mol·m⁻²·s⁻¹. Seedlings were arranged in a split-plot design with a 5 x 6 factorial arrangement of treatments (5 temperatures x 6 provenances). Plants were harvested 12 weeks after treatment initiation and data recorded. Temperature had a significant effect on overall growth with responses to temperature varying according to provenance. There was a highly significant ($P \leq 0.0001$) temperature x provenance interaction for height, stem caliper (measured below the lowest leaf), and foliar, stem, root, and shoot (foliar dry weight + stem dry weight) dry weights. Top and root dry weights were maximized for the

northern provenances (Connecticut and Massachusetts) at 22/18 °C. At 26/22 °C and 30/26 °C, the northern provenances (Connecticut and Massachusetts) had the lowest top and root dry weights. However, the southern provenances (Alabama, Florida, and North Carolina) had the greatest top dry weights at 26/22 °C. At 30/26 °C, the southern provenances (Alabama and Florida) and the New Jersey provenance had the greatest top dry weights but they were not significantly different from 26/22 °C. Root dry weights were not significantly different between 26/22 °C and 30/26 °C for the Alabama and New Jersey provenances, but were significantly different for the North Carolina and Florida provenances. Regardless of provenance, dramatic reductions occurred for all growth measurements when temperatures exceeded 30/26 °C. For top and root dry weights, there were no significant differences among the six provenances at 34/30 °C and 38/34 °C. All plants at the highest temperatures of 38/34 °C did not survive by week 8.

384

Media Temperature in Above-ground and In-ground Pot-in-Pot Container Systems

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In-ground, pot-in-pot (PNP) systems control container blow-over and buffer media temperatures. At least two nursery container manufacturers have recently introduced above-ground, PNP systems to reduce installation cost, overcome land use inflexibility, and eliminate root growth into drainage systems. Above-ground, PNP systems eliminate some of the problems associated with an in-ground PNP system, but little is known about how it compares with in-ground PNP's attributes; specifically media temperature buffering. Fifteen-gallon containers of *Ligustrum japonicum* var. 'Repandens' were installed in May 1997 at a nursery in Moncks Corner, S.C. In-ground PNP; conventional pot placement; and two, commercial, above-ground PNP systems were used as treatments with 12 replications. Four of the replications contained six thermocouples in each treatment. Thermocouples were placed in the top and middle of the container media at three orientations: East-northeast, south, and center. During hot weather studies the two above-ground PNP configurations buffered media temperature deviation ranges slightly when compared to conventional pot production, but not nearly as much as the in-ground PNP configuration. Media temperatures rose more slowly during the daylight hours in the above-ground PNP systems than in conventional pots, but eventually approached similar temperature peaks. Neither above-ground PNP treatment cooled to the low temperature levels of the conventional treatment overnight. The in-ground PNP treatment experienced less temperature deviations than the other three treatments and rarely exceeded 32 °C (90 °F). Measurements of biomass and growth were not different among the above-ground pot-in-pot and the conventional pots, yet the in-ground treatments had a larger growth index and biomass weight. Data for cold weather is currently being collected and will be available for this presentation.

385

Critical Heat Thresholds for Root Tissue of Two Golden Barberrry Cultivars

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Limited information exists for container production of golden barberrry cultivars. The objective of this study was to evaluate root thermostability of container-grown *Berberis thunbergii* 'Monlers' (Gold Nugget™) and *Berberis* sp. 'Bailsel' (Golden Carousel™). Bare root cuttings were planted in 2.7-L containers in an amended 6 pinebark : 1 sand (v/v) substrate in Apr. 1997. Plants were grown under overhead irrigation for 6 months in a completely randomized block design. Young, unsuberized root tips (1.0–2.5 cm), were subjected to temperature treatments from 20 to 63 °C in a thermostatically controlled water bath prior to electrolyte leakage determinations. 'Golden Carousel' was more heat-tolerant (critical temperature midpoint = 49.4 ± 0.3 °C) than 'Monlers' (critical temperature midpoint = 48.0 ± 0.4 °C). Implications of these differences for container production will be discussed.

386

Annual Evapotranspiration and Crop Coefficients of *Ligustrum japonica* Growing in Three Container Sizes

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The objective of this study was to determine crop coefficients (K_c) for *Ligustrum japonica* growing in three container sizes using the Penman equation to calculate reference evapotranspiration (ET_R). Rooted cuttings were transplanted into 3-liter containers and upcanned as needed into 10- and 23-L containers. Production was scheduled such that a series of plants in each container size were about 2 months from commercial marketable size every 4 months. Beginning 1 Jan. 1995 until 31 Dec. 1996, three uniform plants of each size were suspended in weighing lysimeters and surrounded by similar size plants filling an area 3.7 by 4.9 m. Plants within each area were overhead irrigated at 2000 h as needed, based on a 30% moisture allowed deficit. Plants were exchanged every 4 months such that the annual mean size was that of a marketable plant. Actual evapotranspiration (ET_A) was calculated from half-hour measurements of each plant's weight and adjusted for rainfall. From these and daily calculated ET_R , K_c were determined for each size of container. K_c s ranged from 1.06 to 1.50 when ET_A was converted to mm/day based on allocated bed space. Comparisons of volumes of supplemental irrigation to ET_A and effects of assumptions required in converting ET_A to mm/day will be discussed.

387

Overwinter Survival of Plants in Closed, Insulated Rootzone Containers

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Growth and overwinter survival of tree–shrub–groundcover plant combinations in above-grade closed, insulated rootzone containers (CIRC) are being evaluated at Morton Arboretum where winter air temperatures below –11.1 °C (12 °F) are not uncommon. Two-inch-thick extruded polystyrene foam board insulating liner enclosed the rootzone compartment. Triple expanding foam applied where the top insulating board surrounds the above-container plant stems completed the seal preventing heat–moisture transfer and separating the root and shoot environments. Water reservoirs (6-inch depth) in the base of the containers provide additional volume heat capacity. Three plants (tree, shrub, groundcover) were installed in each CIRC. In this preliminary experiment, two 300-gal CIRC are planted with *Picea glauca* 'Conica' (Dwarf Alberta Spruce), *Pinus mugo* 'pumilio' (Dwarf Mugo Pine), and *Potentilla fruticosa* 'Goldfinger'. The two 200-gal CIRC are planted with *Acer ginnala* 'Mondy' TM (Red Rhapsody Maple), and *Hedera helix* 'Bulgaria' and 'Silver Dust'. Control plants are in a field nursery. Within the insulated containers, temperature fluctuations are less extreme than outside. Temperatures within the CIRC have not been below –2.22 °C (28 °F) even when exterior temperatures have hovered at below –11.1 °C (12 °F). Shoot cold hardiness of plants in the closed, insulated containers and of control plants in the field nursery will be compared.

388

Stem Cold Hardiness, Leaf Heat Tolerance, Growth, and Performance of Six Japanese Maples (*Acer palmatum*) in Northern Illinois

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Six different Japanese Maples (*Acer palmatum*) cultivars 'Water Fall', 'Burgundy Lace', 'Crimson Queen', 'Oshio-Beni', 'SangoKaKu', and 'Bloodgood' from Monrovia Nursery were planted in a randomized block design on 4 June 1997 at the The Morton Arboretum. Leaf heat tolerance was evaluated by measuring ion leakage of the leaf tissue at 25–60 °C in July, Aug., and Sept. 1997. The LT_{50} (the temperature at which 50% of the tissues were injured) of all the cultivars were higher in July (≈53 °C) and were lower in September (≈47 °C). Water content of the leaf tissues were higher in July compare to August and September and were not related to heat tolerance of most cultivars. Stem cold hardiness was performed by artificial freezing tests in Oct., Dec., and Feb. 1997/98. The Lowest Survival Temperature (LST) for the most hardy to least hardy cultivars in October and December were: 'Burgundy Lace' (–15, –27 °C), 'Bloodgood' (–18, –24 °C), 'Oshio-Beni' (–15, –24 °C), 'Crimson Queen' (–15, –18 °C), 'Water Fall' (–9, –18 °C) and 'SangoKaKu' (–9, –12 °C), respectively. Growth, dormancy development, spring budbreak and performance of these cultivars will be compared.

Membrane Thermostability for Root Tissue of Red and Freeman Maple Cultivars

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Six red (*Acer rubrum* 'Autumn Flame', 'Fairview Flame', 'Franksred', 'Landsburg', 'Northwood', and 'October Glory') and three Freeman (*A. x freemanii* 'Armstrong', 'Celzam', and 'Jeffersred') maple cultivars originating in different parts of the United States were grown in containers in 1995 and 1996 prior to laboratory procedures to determine root cell membrane thermostability. Electrolyte leakage from excised root tissue exposed for 30 min to temperatures ranging from 20 to 63 °C, was used to assess cellular injury of unsuberized, current season, fine roots. The critical killing temperatures of root tissue of cultivars evaluated ranged from 52.0 ± 0.8 °C to 53.3 ± 0.5 °C, indicating minimal differences in root membrane thermostability among the selections evaluated. Critical temperatures for cultivars selected from the northern part of the native range did not differ from cultivars originating elsewhere. Implications of these differences for container production will be discussed.

49 ORAL SESSION 9 (Abstr. 390–396) Fruits—Flowering/Abscission/Thinning

390

Effects of AVG, NAA, Ethephon, and Summer Pruning on Pre-harvest Drop and Fruit Quality of 'McIntosh'

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Ethylene production increases dramatically during maturation and ripening of 'McIntosh' apples, frequently resulting in preharvest drop and accelerated fruit softening. As harvest approaches, commercial growers must balance the need for color development with minimizing fruit softening and drop. The effects of plant growth regulators and summer pruning on this balance were evaluated in this study. Treatments were applied to trees in the Mid-Hudson in 1995 and 1996 and a subset of growth regulator treatments was applied in the Champlain Valley in 1996. NAA (naphthalene acetic acid) significantly reduced drop on only one sample date in only one of the three trials. Ethephon (2-chloroethylphosphonic acid) at 150 ppm plus 10 ppm NAA, accelerated ripening and permitted harvest before substantial drop occurred, but earlier harvest resulted in smaller fruit size. AVG (aminoethoxy vinyl glycine) at 124 gram a.i./ha, on otherwise untreated trees, significantly delayed drop compared to the controls in two of three trials and resulted in better fruit firmness out of storage. Use of ethephon on AVG-treated trees significantly enhanced red color but also accelerated drop, although drop was reduced compared to ethephon only treatment. Late summer pruning significantly accelerated red color development, drop and ripening in both years. Pruning 16 Aug. 1996 significantly accelerated drop compared to pruning 1 Aug. 1996. Combining AVG application and pruning on 16 Aug. 1996 resulted in improved color without increasing drop compared to controls.

391

Interaction Between CPPU and NAA on Fruit Thinning and Fruit Development in Selected Apple Cultivars

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NAA is used extensively for fruit thinning of apples to increase fruit size and to promote return bloom. In some cultivars, even if thinning is achieved, fruit size at harvest may be less than expected based on crop load. CPPU, N-(2-chloro-4-pyridinyl)-N-phenylurea, has been shown to increase fruit growth in apples, grapes, and kiwi. We evaluated combinations of NAA and CPPU on thinning, fruit growth and return bloom in Redchief 'Delicious', 'Elstar', and 'Gloster'. CPPU was

applied at 5 mg·L⁻¹ (based on 0 to 10 mg·L⁻¹ response curve) in combination with 15 mg·L⁻¹ NAA as high-volume sprays at 7 to 10 mm KFD. Yield and fruit size distribution (on total yield) were used as index of response. In 'Delicious', CPPU (3-year study) increased % large (70 mm+) fruit, but in the presence of NAA % large fruit was reduced 2 of the 3 years. CPPU did not induce significant thinning. There were no significant effects on color or soluble solids; firmness was increased slightly and seed number reduced. The L/D ratio was increased and uneven lobe and carpel development was common. CPPU had no significant effect on return bloom in presence or absence of NAA, but NAA increased bloom in both the presence and absence of CPPU. With 'Elstar' (2-year study) there was no significant thinning with either chemical, but CPPU increased mean fruit size and % large (70–80 mm) fruit over nonthinned, but not significantly greater than NAA alone. There were no significant differences in firmness, color, soluble solids or seed number. NAA + CPPU did not inhibit fruit growth or cause excessive uneven carpel development. Frost damage reduced crop load in 'Gloster' where results were similar to 'Elstar' except seed number was reduced by the NAA + CPPU combination.

392

Effect of Seed Number on Preharvest Drop and Fruit Mass of Three Apple Cultivars

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The factors controlling preharvest drop are poorly understood. The number of viable seeds in apple fruit has been associated with fruits retained following June drop. Three experiments were conducted to determine the effect of seed number on time of preharvest drop. In two experiments treatments were imposed to induce variability in seed numbers. Trees of 'Redchief Delicious' were covered with 92% shade fabric for 0, 1, 2, or 3 days when fruits averaged 13 mm in diameter. In a second experiment 'Redchief Delicious', 'Smoothie', and 'Commander York' flowers had 0, 1, 2, 3, 4, or all 5 stigmas excised at early "popcorn" stage and the remaining stigmas were hand-pollinated. The third experiment investigated drop of the same three cultivars as affected by the natural variability in seed number. Fruits were gathered from under the trees daily from 26 Aug. until all the fruits had fallen from the trees. Fruits were weighed and the number of filled, large aborted and small aborted seeds were counted. Neither total number of seeds, number of filled seeds, total number of aborted seeds, number of large aborted seeds nor number of small aborted seeds explained any appreciable amount of the variation in date of drop ($R^2 < 0.13$). Fruit mass was positively related to seed number for 'Delicious', but not for 'Smoothie' or 'York'.

393

Effect of Split Applications of GA₃ on Flowerbud Density of Mature Peach Trees

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The effect of divided GA₃ applications on flowerbud density was investigated using mature 'Redhaven' and 'Sweet Sue' peach trees treated at 6, 12, and 24 g/acre in 1994 and 'Redhaven' and 'Loring', treated at 12, 24, and 48 g/acre in 1995. Flowerbud densities were found to be reduced, except in the cultivar Sweet Sue, which had poor vegetative vigor. The reduction averaged 10% for the 48 g/acre, single, and 32% for the split application of the same rate. For both 'Loring' and 'Redhaven', it was the basal most 10 cm that showed the largest effect of the split applications, flowerbud density was 86% (single) vs. 28% of control (split) for 'Loring' and 94% vs. 42% for 'Redhaven'. For the rest of the shoot the differences were not as marked, but were larger for the younger, more vigorous 'Loring'. Vegetative bud densities were found to be increased in all cultivars, with the split applications showing a larger effect. The increases were most marked in the distal most 10 cm of the shoots, at the 48 g/acre rate densities were 127% vs. 195% of control for 'Loring' and 159% vs. 233% for 'Redhaven'. Other growth characteristics (node and blind node density, shoot length) were also evaluated, but significant changes were rarely found. Comparing the number of flower- and vegetative buds per node revealed that the GA₃ applications were effective on nodes that had formed 10 to 15 nodes prior to the number of nodes present at spray application. The effect of split GA₃ applications was visible on a larger number of nodes, showing that split applications were able to affect a larger portion of the continuously elongating shoot.

Thinning Peaches by Heat

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Flower buds in their last stages prior to opening, open flowers and small fruitlets are the most sensitive organs to frost damage. Such effect of low temperature is well-known as it poses an economical hazard in growing stone fruits in many countries. Heat effect on flower buds and flowers is less known simply because it is not common at time of bloom in most locations where such species are grown. Many of the low-chill early maturing peaches and nectarines set very heavily in subtropical climate and require a major input of manual thinning in order to obtain marketable fruit. As the level of fruitset is usually very high, thinning is been carried out during full bloom. With increase in costs of manual labor, this element becomes the critical one in producing such fruits economically. Up till now, no chemical or physical mean can replace hand-thinning in these early cultivars effectively. During our work with greenhouse-grown stone fruits we came across the enormous sensitivity of non-dormant flower buds as well as flowers to high temperatures. Avoiding excessive heat close to, and during bloom, became number one concern in the practice of growing stone fruits in greenhouses. By using container-grown peaches and temperature-controlled chambers in a phytotron, we were able to quantify the effect of heat on flower buds with the potential of obtaining controlled damage leading to the required level of thinning. Trials with potted and with orchard grown trees will be reported.

395

Bloom Thinning of Peaches with Gibberellic Acid in the Southeast

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Thinning peach fruit in the spring of the year is one of the most labor- and capital-intensive operations for peach growers in the southeast. In addition, fruit size can be negatively affected if peach thinning is delayed. The objective of this study was to evaluate the application of gibberellic acid (4% GA₃, Ralex—Abbott Labs) in June to reduce peach bloom the following spring. Ralex was applied in June 1995 and 1996 to 'Contender' peaches. Bloom density was evaluated in Spring 1996 and 1997 from long and short shoots from the higher and lower portions of the tree's canopy. Applications in 1995 were to trees with a crop load while applications in 1996 were to trees without a crop due to a spring freeze. Bloom densities in 1997 were 300% greater than bloom densities in 1996. The five rates of material evaluated were 0, 59, 79, 99, and 119 g/ha. In 1996, bloom density was significantly reduced with Ralex applications with the greatest reduction with the 99 and 119 g/ha application rates. However, in 1997 only slight differences were detected between all treatments with no difference between the control and 79-g/ha rate.

396

Control of Dormancy and Budbreak in Sweet Cherry (*Prunus avium* L.) cv 'Bing' with Surfactant + Calcium Ammonium Nitrate and Hydrogen Cyanamide

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Continuing trials (1995–present) advanced budbreak and flowering with a surfactant and calcium ammonium nitrate (CAN17), and in 1997, hydrogen cyanamide (HCN). Chilling in 1996–1997 was marginal in San Joaquin County (SJ, 830 chill hours, 18 Feb.), and low in San Benito County (SB, 612 chill hours, 21 Feb.). When we used the "45 °F" chilling model, the most effective surfactant + nitrate treatment timings for both locations were similar by chill accumulation (≈72 % to 82% of required chilling for 'Bing' = 850–880 chill hours), although the two locations differed in total chill accumulation and date of effective treatment. Full bloom (FB) was advanced by 1 week with 4% HCN in SJ, followed by 2% surfactant + 25% calcium ammonium nitrate applied on 21 Jan. (700 chill hours), compared to the untreated control. Bloom duration (full bloom to petal fall) was compressed most by surfactant and CAN17. Bloom in SB was also most advanced by HCN, followed by 2% surfactant + 25% CAN17 applied on 21 Feb. (612 chill hours). Fruit set was improved in SB by surfactant and CAN17 in mid-February; set was too low, however, for real impact. In SJ and SB, HCN advanced fruit maturity most, followed by surfactant and CAN17 applied 21 Jan.; these fruits were softer.

We believe that, in order for treatments to be effective in advancing budbreak and full bloom, some minimum amount of chilling must be accumulated prior to application (perhaps 60% to 75% of chilling requirement). We have also determined that where chilling is well below minimum requirement, higher rates of CAN (25%) are necessary to advance bloom. A further advantage of using Armobreak + CAN is improved N level in buds and bark after treatment (1997).

58 ORAL SESSION 10 (Abstr. 397–401) Vegetable Crops—Breeding & Genetics

397

The Characterization of Jalapeno (*Capsicum annuum*) Germplasm Based on RAPD Markers and Morphology

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Characterization of germplasm collections is often criticized due to the lack of relevance given to "unadapted" germplasm by commercial breeders. Within *Capsicum*, only specific pod types are commercially important. Jalapeno peppers are becoming increasingly important due to the increase in sale of *Capsicum*-based food products. Unfortunately, few Jalapeno cultivars are available to growers. A *Capsicum* is classified as a Jalapeno based largely on pod shape, rendering a liberal definition of a Jalapeno. Curators and breeders with knowledge of pepper collections submitted accessions characterized as a Jalapeno. These accessions were grown at two locations to cull accessions not included in the Jalapeno market class. Accessions were characterized for traits important to commercial breeders at both locations. In addition, accessions were characterized using a set of RAPD markers dispersed throughout the genome in a separate mapping population. A subset, created from RAPD marker-based estimates of genetic distance, was created to represent the range of genetic diversity available among all Jalapeno accessions analyzed. These accessions will add genetic diversity to a breeding program without changing pod type expectations. The comparison between Jalapeno accessions and currently grown Jalapeno cultivars was examined based on differences in RAPD marker frequency. In addition, differences in marker frequencies were used to compare Jalapenos and other *C. annuum* market types also characterized with RAPD markers. The characterization of Jalapenos will assist breeders in their future efforts to diversify their *Capsicum* breeding base.

398

AFLP-derived, Codominant Markers for Locus-specific Applications

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The amplified fragment length polymorphism (AFLP) is a powerful marker, allowing rapid and simultaneous evaluation of multiple potentially polymorphic sites. Although well-adapted to linkage mapping and diversity assessment, AFLPs are primarily dominant in nature. Dominance, relatively high cost, and technological difficulty limit use of AFLPs for marker-aided selection and other locus-specific applications. In carrot the *Y₂* locus conditions carotene accumulation in the root xylem. We identified AFLP fragments linked to the dominant *Y₂* allele and pursued conversion of those fragments to codominant, PCR-based forms useful for locus-specific applications. The short length of AFLPs (≈60 to 500 bp) precludes development of longer, more specific primers as in SCAR development. Instead, using sequence information from cloned AFLP fragments for primer design, regions outside of the original fragment were amplified by inverse PCR or ligation-mediated PCR, cloned, and sequenced. Differences in sequences associated with *Y₂* vs. *y₂* allowed development of simple PCR assays differentiating those alleles. PCR primers flanking an insertion associated with the recessive allele amplified differently sized products for the two *Y₂* alleles in one assay. This assay is rapid, technologically simple (requiring no radioactivity and little advanced training or equipment), reliable, inexpensive, and codominant. Our PCR assay has a variety of large scale, locus-specific applications including genotyping diverse carrot cultivars and wild and feral populations. Efforts are underway to improve upon conversion technology and to more extensively test the techniques we have developed.

Molecular Markers Linked to Quantitative Trait Loci for Anthracnose Resistance in Tomato

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Random amplified polymorphic DNA (RAPD) and amplified fragment length polymorphism (AFLP) markers linked to quantitative trait loci (QTL) involved in tomato anthracnose resistance were identified in an F_2 population of tomato (*Lycopersicon esculentum*) segregating for anthracnose resistance. The F_2 population was developed from the cross of an unadapted and small-fruited, but highly anthracnose-resistant *L. esculentum* accession and an adapted, but anthracnose-susceptible processing type tomato. Resistance to anthracnose caused by the fungal pathogen *Colletotrichum coccodes* is estimated to be controlled by at least three genes or chromosomal regions in this cross. One-thousand RAPD random primers and 64 AFLP primer pairs were screened for polymorphisms between the parental lines. Primers or primer pairs which differentiated the anthracnose resistant and susceptible parents were utilized to screen the F_2 population for detection of QTL. Using single-factor analysis of variance, a number of markers, including six unmapped RAPD markers were identified that were significantly associated with resistance. Mapping of marker loci and their potential use in marker assisted breeding will be discussed.

400

Identification of Molecular Markers Linked to Tomato Mottle Virus Resistance Genes

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Tomato mottle virus (ToMoV) is a whitefly transmitted geminivirus threatening the Florida fresh-market tomato (*Lycopersicon esculentum* Mill.) industry. ToMoV resistance was identified in *Lycopersicon chilense* accessions LA 1932, LA 1938, LA 1969, and LA 2779, and introgressed into tomato breeding lines. Inheritance studies of populations derived from resistant accessions of LA 1932 and LA 1938 suggest that introgressed resistance is largely additive and multigenic. RAPD polymorphisms were identified using 800 arbitrary primers (decamers), and 88 polymorphisms with good repeatability were identified. Of these, 45 polymorphisms were identified in breeding lines derived from two or more of the four accessions. Analysis of segregating F_2 populations has resulted in association of RAPD markers with geminivirus resistance genes, and markers have been identified that are common to different *L. chilense* resistance sources. Linkage of several markers to each other and to the self pruning (*sp*) and β -carotene (*B*) loci on chromosome 6 was also determined.

401

Identification of PCR-based Molecular Markers Linked to *B*, A Carotenoid-related Gene in Tomato

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β -carotene is the principal provitamin A carotenoid found in tomato fruits and makes a significant contribution to the fruits nutritional value. The dominant *B* gene conditions high levels of β -carotene in ripe tomato fruits. PCR-based molecular markers, including random amplified polymorphic DNA (RAPD) and amplified fragment length polymorphism (AFLP), were used to identify marker linkage to the *B* locus. The study was conducted using a near-isogenic line (NIL) of the cultivar Rutgers isogenic for the *B* locus and bulk segregant analysis of an interspecific F_2 population segregating for the *B* locus, which was derived from the cross of *Lycopersicon cheesmanii* accession LA 317 x *L. esculentum* cv. Floradade. Sixty-four AFLP primer pairs and 1018 arbitrary RAPD primers were screened for polymorphism between the pair of NILs and between the two bulks. A number of amplified RAPD and AFLP products were identified that were present in one line or bulk but not the other. Marker linkage with the *B* locus was confirmed by checking individual samples from the F_2 and BC populations. Two RAPD markers were confirmed tightly linked with the *B* phenotype using the interspecific F_2 population. Similarly, a single AFLP marker was identified with close linkage to the *B* phenotype using the NIL F_2 population. The markers identified in this study can be useful in breeding programs with marker assisted selection and, if very tightly linked, as a starting point to isolate the gene.

59 ORAL SESSION 11 (Abstr. 402–406) Woody Ornamentals/Landscape/Turf— Nutrition

402

Rate of Fertilizer Application and Pot-in-Pot Production Increase Growth of Heritage River Birch

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A study was conducted to compare the effects of three rates of fertilizer (High N–Southern Formula, 23N–1.7P–6.6K at 1.3, 1.7, and 2.0 kg N/m³) and two production systems [pot-in-pot (PIP) or conventional above-ground (CAG)] on the growth of Heritage river birch (*Betula nigra* L. 'Cully') in 26 L (#7) containers. Plants grown PIP had higher shoot dry weight (20%), root dry weight (31%), total biomass (27%) and root:shoot ratios (12%). Fertilizer rate increased shoot dry weights but decreased root:shoot ratios. Rate of fertilizer application influenced foliar Mg, Zn, and Fe while production system had no effect. The foliar P:Zn ratio increased linearly as rate of fertilizer increased. Soluble salts and NO₃-N in the leachate increased linearly as rate of fertilizer increased at 15 and 60 days after application (DAA), whereas the response was curvilinear at 120 DAA. When different, nutrient concentrations in the leachate were greater for plants grown CAG. Fertilizer longevity was greater when the PIP system was used, presumably due to lower substrate temperatures during the experiment period.

403

Fertilizer Placement Effects on Growing Medium Nutrient Distribution and Root Growth of Roses

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The effect of localized controlled-release fertilizer (CRF) topdressing applications on medium nutrient distribution and root growth was evaluated in containerized roses (20-L pots with peat-based medium). Small samplers were used to monitor the soil solution nutrient status in four vertically oriented quadrants of the medium profile. Average electrical conductivity (EC) and nitrogen concentrations ([N]) found in quadrants beneath the localized CRF supplies were significantly higher (from 1.6 up to 5.8 times) than in the rest of the quadrants. Nutrient distribution patterns in pots receiving evenly distributed CRF applications were affected by the placement of irrigation spray-stakes, with higher EC and [N] in quadrants receiving the least water. After a 12 week experimental period no significant differences in average new root mass and length densities were observed for pots receiving either localized or evenly distributed CRF applications. Reductions in root growth parameters were, however, observed in those quadrants farther away from the irrigation spray-stakes. Results from pots irrigated with a Hoagland nutrient solution applied with either a 360-degree spray-stakes or localized drippers showed a more prominent effect of water and nutrient localization on root growth.

404

Lime and Micronutrient Additions to Pine Bark Affect Growth of Nine Landscape Tree Species

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Although the practice of amending a pine bark substrate with lime and micronutrients is common in the nursery industry, the effect of these amendments on the growth of container-grown landscape trees has not been documented. The objective of this study was to determine the lime and micronutrient preferences for a wide range of landscape trees grown in pine bark. Approximately 10 seedlings per pot for each of nine species of trees were greenhouse-grown in pine bark-filled 3-gal containers. Initial pH of the bark was 4.7. Preplant bark treatments were: unamended (control), dolomitic lime only (3.57 kg·m⁻³), micronutrients only (Micromax™, 0.89 kg·m⁻³), or lime plus micronutrients (previously stated rates). All seedlings except one per pot were harvested at week 12, and shoot height was determined. Remaining seedlings were grown until week 19, at which time final shoot height

was determined. Bark solutions were extracted (pour-through method) at week 7. Adding micronutrients increased height for all species by week 19. Adding lime either had no effect on height or suppressed height. Micronutrient additions increased solution concentrations of Ca, Fe, Mn, Cu, and Zn, but in the presence of lime these increases were diminished. Under the conditions of this experiment, amending pine bark with micronutrients is essential for maximum height of these tree species, while a lime amendment is unnecessary.

405

The Effect of Media and Lime Incorporation on Growth of Three Azaleas

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The influence of media and lime incorporation was investigated for a satsuki (*Rhododendron eriocarpum* 'Pink Gumpo'), a kurume (*Rhododendron obtusum* 'Girard's rose'), and a Southern indica azalea (*Rhododendron indicum* 'Formosa'). Uniform liners of each cultivar were planted into 2.8-L containers on 11 Apr. 1997 and placed under shade. Media evaluated included 4 pine bark (pb):0 coconut coir pith (cc), 3 pb:1 peatmoss, 3 pb:1 cc, 2 pb:2 cc, 1 pb:3 cc, and 0 pb:4 cc. Dolomitic limestone was incorporated at 0 or 1.2 kg/m³, and Micromax was incorporated at 0.6 kg/m³. Data collected included pH and electrical conductivity and growth. Liming increased pH for 4 pb:0 cc and 4 pb:1 peatmoss treatments compared to unlimed 4 pb:0 cc and 4 pb:1 peat moss treatments 0 DAT, respectively, but electrical conductivity measurements were similar. By 240 DAT, pH measurements for all treatments were similar. Medium composed of 4 pb:0 cc and dolomitic limestone had higher conductivity compared to all other treatments. Growth of Formosa was only impacted when plants grown in 3 pb:1 peat moss or 2 pb:2 cc with no dolomitic limestone were compared to plants grown in 4 pb:0 cc and dolomitic limestone. Addition of dolomitic limestone did not influence growth within any media. Growth of Girard's rose was higher for plants grown in 1 pb:3 cc regardless of dolomitic limestone amendment, and growth was lower for plants grown in 4 pb:0 cc with no dolomitic limestone although there were similarities between other treatments. Incorporation of dolomitic limestone increased growth when plants were grown in 4 pb:0 cc. Growth of pink gumpo was not influenced by media.

406

Influence of Nitrogen and Potassium on Three Zoysiagrasses

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Zoysiagrass has great potential for use in the Gulf Coast states as a turfgrass. There has been minimal research on the nitrogen (N) and potassium (K) fertility response of zoysiagrass and the effect on turf color, quality, and nutrient content. The objective of this study was to evaluate the effects of N and K fertility on zoysiagrass. A study was conducted on three zoysiagrasses: *Zoysia japonica* x *Z. tenuifolia* Willd. ex Trin. ('Emerald'); *Z. japonica* Steud. ('Meyer'); and *Z. matrella*. The N and K treatment combinations consisted of high (H) and low (L) rates of N and K at the following levels: N levels of 454 and 227 g N/92.9 m² per month and K levels of 454 and 227 g N/92.9 m² per month. The treatment combinations were (N and K): HH, HL, LH, and LL and were applied in two split applications monthly from July through November. The study was a randomized complete-block design with three replications. All plots received two applications of a micronutrient fertilizer (late June and August), were irrigated as needed, and maintained at a height of 3.8 cm. Color, density, texture, uniformity, and quality were determined visually for each month. Plant tissue samples were collected (September) and analyzed for macronutrient and micronutrient contents. There were significant differences for color, density, and quality in the following months: September (color and density); October (quality); and November (color and quality). There were differences in leaf texture for all months. There were significant differences for N, magnesium (Mg), and K contents but there were no differences for any micronutrient. This study indicated that all three zoysiagrasses provided acceptable color and quality during the summer and fall, and that N and K rates affected N, K, and Mg contents in the plant.

60 ORAL SESSION 12 (Abstr. 407–411) Small Fruit & Viticulture—Genetics

407

Intersubgeneric Hybridization between *Muscadinia* and *Euvitis* Species

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The genus *Vitis* contains two subgenera: *Euvitis* Planch. (with the common name bunch grapes) and *Muscadinia* Planch. (with the common name muscadine grapes). The muscadine grapes (*V. rotundifolia*) are originated and limited to the southeastern United States and are distinguished from the *Euvitis* species morphologically and cytologically. They are characterized by high disease and pest resistance, and unique muscat flavor. Bunch grapes, with a total of 60-plus species, are grown world-wide and can be grouped into the American species, the Asiatic species and the European grape (*V. vinifera*) according to their geographical origination. *V. vinifera*, which is known for good fruit quality, is the predominant commercial species. Attempts to produce *rotundifolia*-*vinifera* hybrids to combine good fruit quality and disease resistance of both into F₁ hybrids have been made by grape breeders for many years. Limited success was only reported when the *V. vinifera* was used as seed parents and it failed vice versa. This study extended the crosses between the *V. rotundifolia* and other *Euvitis* species originated from North America and East Asia to see if hybrids could be produced from any of these crosses. Results indicated that a limited success were achieved in a few crosses [muscadine (female) x *Euvitis* species] while failure occurred in most others. These hybrids may be used as bridges to carry the viticulturally important genes over to the muscadine grapes from *V. vinifera*. Microscopic study also revealed that the difficulty of hybridization between *Muscadinia* x *Euvitis* is due to the pre-fertilization barriers.

408

Unknown Cultivars of Cold-hardy Grape Can Be Successfully Identified by Their Simple Sequence Repeat (SSR) Fingerprints

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Simple sequence repeat DNA fragments (SSRs) have been suggested as the method of choice for DNA fingerprinting of grape cultivars. Nevertheless, the use of SSRs as a practical fingerprinting method is not without its pitfalls. For example, when the polymerase chain reaction is used to amplify SSR sequences, potentially confusing "stutter" bands may occur, or there may be non-template directed addition of an "A" to the end of synthesized fragments, or other artifactual amplification products may be produced. Since we would like to fingerprint our entire cold-hardy grape collection of ~1300 cultivars, we decided to conduct a blind test to determine if SSR fingerprinting actually would be practical in our circumstances. First, SSR fingerprints were established for 45 commercially important cool-climate grape cultivars, the known standards. Then, SSR fingerprints were produced for 44 "unknown" cultivars grown in the Finger Lakes Region of New York. The identities of these were known only to the third author. To independently identify these "unknowns," their fingerprints were compared to those of the known standards. By this means, 42 of the 44 "unknowns" were immediately correctly identified. The identity of one of the two remaining unknowns was truly not known to the vineyard owner; it was identified as Cabernet Franc, a grape commonly grown in the region. The final "unknown" was a plant of Pinot Blanc, whose fingerprint matched those of both the known and the unknown Pinot Gris and Pinot Noir plants, but did not match that of the Pinot Blanc plants used as standards. This was surprising, since all three Pinot's varieties are simply fruit color mutants of the same genotype. Further investigation revealed that the known plants of "Pinot Blanc" had been misidentified, and actually were the cultivar Melon. Thus, identification of the "unknown" Pinot Blanc as Pinot Noir or Pinot Gris was correct, as were the identifications of the 43 other "unknowns."

This study confirmed that SSR fingerprinting is a practical method for identifying cool-climate grape cultivars.

409

Herbicide Tolerance Of Transgenic 'Stevens' Cranberry Plants Depends on the Test Environment

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'Stevens' cranberry was genetically engineered to confer tolerance to the broad spectrum herbicide glufosinate. Initially, herbicide tolerance was verified by spraying greenhouse plants with the commercial formulation Liberty. Although one transformant showed significant tolerance, the tolerance level was below that required to kill goldenrod, a common weed of cranberry beds. This transformant was propagated and the plants established outdoors in a coldframe, yielding a growth form more typical of field-grown plants than that of greenhouse-grown plants. These plants, as well as untransformed cranberry and goldenrod plants, were sprayed with various levels of the herbicide. The transformed plants were not killed at glufosinate concentrations up to 1000 ppm, although delayed growth did occur. Some runner tip injury was observed at 500 ppm as well as widespread shoot tip death at higher levels. The above-ground parts of goldenrod plants were killed at 400 ppm with significant injury at 200 ppm. Untransformed cranberry plants were killed at 300 ppm and had extensive tip death even at 100 ppm. Transformed cranberry plants with confirmed "field" tolerance were re-established in the greenhouse and new vegetative growth was forced. When these plants were sprayed with glufosinate, significant shoot tip injury was observed at levels as low as 100 ppm. The degree of herbicide tolerance of transformed cranberry appears to be modulated by the growth environment, which may affect the expression of the inserted genes or the physiological sensitivity of the impacted tissues.

410

Molecular Responses of Strawberry Fruit to High Carbon Dioxide

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Postharvest strawberry fruit respond beneficially to 20% CO₂ treatment as indicated by enhanced fruit firmness and reduced decay. However, the CO₂ treatment also can cause detrimental effects, such as off-flavor, depending on concentration and length of exposure to CO₂, temperature, and cultivar. To characterize molecular responses of the fruit to high CO₂ treatment, mRNA differential display technique has been used to identify and clone genes differentially expressed in CO₂-treated fruit compared with air-treated fruit at both cold storage (2 °C) and room (20 °C) temperatures. Forty-eight differentially displayed cDNA bands have been selected and grouped into four families: CO₂-induced at both temperatures, CO₂-induced only at low temperature, CO₂ induced at room temperature, and CO₂-repressed ripening cDNAs. These cDNAs are being cloned and sequenced. Genebank database research indicates that alcohol dehydrogenase, spermidine binding protein, and *rbcL* gene are being induced, and ripening-associated genes such as ACC synthase and ACC oxidase are found to be repressed by the CO₂ treatment. Full length of the genes are being obtained by 5'RACE/cDNA library screening methods. Possible function(s) of the genes in responses of strawberry fruit to CO₂, and in relation to other kinds of stress-induced gene expression, will be discussed.

411

Response of Dehydrins to Drought, Low Temperature, and ABA Treatment in Whole Plants and Cell Suspension Cultures of Blueberry

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Previously, three dehydrins of 65, 60, and 14 kDa were identified as the predominant proteins present in cold-acclimated blueberry floral buds. Levels were shown to increase with cold acclimation and decrease with deacclimation and resumption of growth. Recently, a dehydrin cDNA clone was isolated and sequenced, and shown to hybridize to messages likely to encode all three dehydrins. In the present study, expression of dehydrins was examined in blueberry cultivars in response to drought and low-temperature treatment and in cell suspension cultures in response to low temperature and ABA treatment. During 32 days of drought stress, relative shoot water content dropped to 51% to 90%, depend-

ing upon cultivars. For cold stress experiments, cultivars with different chilling requirements and levels of cold hardiness were kept at 4 °C for 5 weeks. Cell suspension cultures were held at 4 °C for up to 2 weeks. For ABA experiment, ABA concentrations ranging from 10⁻³ to 10⁻⁷ M were used. Dehydrins were monitored in response to various treatments at RNA and proteins levels using the cDNA clone and antisera raised against the dehydrins. Interestingly, a previously uncharacterized 30 kDa dehydrin was found to be the major low temperature and ABA-responsive protein in cell suspension cultures.

61 ORAL SESSION 13 (Abstr. 412–419) Herbs/Medicinals

412

Multiple Harvest Yield Response of Microirrigated Herbs to N and K Rates

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Italian parsley (parsley), *Petroselinum crispum*; summer savory (savory), *Satureja hortensis*; sweet marjoram (marjoram), *Origanum majoranna*; and thyme, *Thymus vulgaris*, were evaluated for their yield potential in multiple harvest during the fall–winter–spring (Nov.–June) 1995–96 and (Dec.–June) 1996–97. The herbs were grown with the full-bed polyethylene mulch-micro (trickle) irrigation system at 1x and 2x N and K rates (1x = 0.86 N and 0.71 K, kg/ha per day). Phosphorous was applied pre-plant at 21 kg·ha⁻¹ P with both N and K rates. Parsley, savory, and thyme yields in the first harvest were similar with both N and K rates. Marjoram yields were higher (4.30 t·ha⁻¹) with the 2x than with the 1x N and K rate (2.55 t·ha⁻¹) (*P* < 0.05). For the season, parsley, marjoram, and thyme yields in 1995–96, and parsley and thyme yields in 1996–97 were higher with the 2x than with the 1x N and K rate. Savory yields in both years were similar with the 1x or the 2x N and K rate. Residual concentrations of macro- and micronutrients in the soil at the end of the season were similar with both N and K rates. In the shoots, macro and micronutrient concentrations for the same herb were similar with the two N and K rates. Very high concentrations of Cu, Fe, and Zn were found in the savory shoots at both N and K rates. Zinc concentrations were very high in parsley shoots.

413

The Effect of Mild Water Deficit on Basil Yield and Quality

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Secondary compounds, essential oils, and flavor components of leaf tissue often increase in response to environmental stress. The objective of this study is to determine if a simple measure of soil matric potential could be used to generate mild plant water stress in sweet basil, which would improve the flavor components of the foliage. Sweet basil was grown in Universal Soil Mix with adequate water and fertilization in greenhouses supplied with 18 h of high-pressure sodium supplemental lighting until the third pair of leaves was fully expanded. Aquaprobe matric potential sensors were installed in the center of the pot and soil matric potentials recorded daily. Water was withheld from stressed plants until the soil water potential reached –4 bars. Treatments consisted of one or two stress cycles. Plants were harvested 24 h after rewatering and fresh and dry weights determined. The youngest two fully expanded leaves were placed in zip log bags and used in a taste test. The two water stress treatments decreased leaf fresh weight by 10% and 16%, respectively, decreased total plant dry weight by 6% and 10%, respectively, and had moderate effect on flavor intensity as rated by our taste test panel. The substantial decrease in yield suggests that –4 bars was too severe a stress to be used commercially. The Aquaprobe sensor was an easy to use economical way to monitor soil water and could be useful in regulating watering in a greenhouse environment.

414

Influence of Planting Stock Clove Size, Nitrogen Rate, and Planting Method on Elephant Garlic Production

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To produce large elephant garlic (*Allium ampeloprasum* L.) bulbs in the southeastern United States, stock cloves must be planted in the fall. During extremely cold winters, however, winter survival rates can be very low. A 2-year study was undertaken to examine practices to increase winter survival rates. Two clove sizes (≤ 20 g or >20 g), three nitrogen rates (112, 224, and 336 kg/ha), and three planting methods (flat, mulched, and hilled) were tested in a RCB design with four replications. For all planting methods, cloves were set in a shallow trench and covered with soil to ground level. This was also the flat treatment. For the mulched treatment, 7 cm of straw was spread on top. For the hilled treatment, soil was mounded 10 to 15 cm high over the ground level. Cloves were planted in early October and harvested in mid-June. Use of large planting stock cloves increased winter survival rates during the harsh winter, but had no effect during the mild winter. Both years, winter survival was reduced with the flat treatment. Yields of marketable bulbs were 4 to 5 times higher when >20 g cloves were planted than when ≤ 20 g cloves were used. Nitrogen rate and planting method had no effect on yields. The >20 g cloves also produced larger bulbs than the smaller cloves. Of the three planting methods, the flat treatment produced the smallest bulbs. Bulbs were much larger following the mild winter than the harsh winter.

415

Comparative Study of Various *Hypericum perforatum* Cultivars under Organic Cultivation

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St. John's Wort (*Hypericum perforatum* L.), a perennial from Hypericaceae, is one of the highly esteemed medicinal plants since ancient times. The tops are used for its soothing, calming antidepressant effects, wound healing, antispasmodic, and antiviral effects. Recently it has been found to be a natural substitute for "PROZACTM". So far, most of the commercial supply of St. John's Wort originates from wild collections. Five different cultivars of *Hypericum perforatum* originating from Germany ('Due-1', 'Due-2') Canada (Quebec), United States (TLF-1), and Russia ('Russia') were grown under commercial organic cultivation. *H. perforatum* of Canadian origin (Quebec) and 'TLF-1' from the United States (Washington and Oregon) were of a recent selection, while the German (Due-1, Due-2) and Russian cultivars were selected for higher yield and better concentration of the active constituents (essential oil, hypericin, and other related flavonoids). Seeds obtained from these cultivars were directly sown in the field, using animal manure, in Trout Lake Farm, Wash. There was a significant difference among the cultivars in morphology, flowering period, yield, and content of the essential oil. Cultivars Due-1, Due-2, and Russia showed an erect growth, with uniform flowering time and pattern, indicating the suitability of these cultivars for mechanical harvesting and better exposure of the flowers to sunlight. The highest herb yield was obtained from 'TLF-1', while the lowest was obtained from 'Quebec'. Cultivar TLF-1 came to flowering the latest, while 'Due-1' was recorded to flower earliest and had the lowest shoot yield. The essential oil content of 'Due-1', 'Due-2' and 'Russia' was significantly higher than 'Quebec' and 'TLF-1' cultivars.

416

Variability in Yield, Essential Oil Content and Seed Germination of *Lomatium dissectum*

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Lomatium dissectum (Torrey & Gray) Mathias & Constance, a perennial from the Apiaceae, has been among important traditional medicinal plants of the native North Americans for thousands of years. Preparations from the tuber are used to improve the general well-being, immune system, and adaptation. Its formulations with other herbs is used in cosmetics for skin regeneration, and treatment of psoriasis. *L. dissectum* is normally collected from the wild for commercial processing. As the demand for the raw material is increasing, there is a growing danger of genetic erosion of the wild species. In addition to this, wild collection does not guarantee regular availability, quality, and exact botanical identity. The objective of this investigation was, therefore, to study the variability in tuber and seed yield, essential oil content, and find effective method of increasing seed germination and develop improved cultivars, suitable for commercial cultivation. We found significant variations in tuber and seed yield/plant, and essential oil content in the tubers. The color of the oil varied from pale green to deep green.

The intensity and composition of the aroma of the oil obtained from individual plants was also found to vary significantly. We carried out investigations with microbial seed pretreatment under laboratory and field conditions, with varying concentrations and length of seed soaking. The microbial (RIBAVTM) seed pretreatment for 20 min, at a concentration of 20% under laboratory conditions resulted in a 99.2% germination, while control variants had only 18% to 26% seed germination. Pretreated seeds took significantly less time for germination compared to the control. Similar results were recorded for seeds sown under field conditions. Seedlings from pretreated seeds showed vigorous growth and better field establishment, compared to the control variants.

417

Gamma-linolenic Acid Levels of Native Species of Evening Primrose (*Oenothera*)

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Gamma-linolenic acid (GLA) is an essential fatty acid that serves as a precursor for prostaglandin biosynthesis in humans. GLA was first extracted from the seed oils of evening primrose, and currently *Oenothera biennis* is the major commercial source of evening primrose oil. In this study, native species of the Onagraceae family occurring in semiarid regions of Texas were surveyed. Seeds from these native populations were collected and oil extracted for analysis of fatty acid composition. Gamma-linolenic acid levels ranged from less than 1% to 8% and was species specific. GLA levels from field-grown plants from native seed were compared with GLA levels from corresponding native populations. Two species of native *Oenothera* were evaluated for relative levels of GLA over several harvest dates.

418

Developmental Variations in the Content of Active Substances and Nutrients in *Echinacea purpurea*

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Echinaceae from the Asteraceae family has been among the top 10 marketed herbs in North America and Europe. So far, only a limited amount of Echinaceae originate from commercial cultivation. *Echinacea purpurea* has been commercially cultivated in the United States since the mid 1970s, in Russia since 1935, while in Europe since the 1960s. However, there has been no published information in the English language on methods of cultivation, expected yields, limiting factors, nutrient requirements, and the optimum plant development stage to obtain maximum yield and concentration of the biologically active substances for pharmaceutical and cosmetic processing. The objective of this investigation was, therefore, to study the general distribution of major nutrients and biologically active substances and the relationship between the two groups, and the pattern of the accumulation of cichoric acid, echinacoside, isobutylamides (tetraenes) and essential oil in commercially cultivated *Echinacea purpurea*. There was a significant variation in the content of essential oil, cichoric acid, and isobutylamides (tetraenes) in different organs and stages of the plant development. Similarly, the difference in the distribution of N, P, K, Ca, Mg, and Fe in different organs and developmental stages is demonstrated. The correlation between the content of the active substances and nutrients is demonstrated, while recommendations for an optimum harvesting stage and date are made.

419

Response of Plant Tissue Cultures to Various Light Spectra and Ultra-high Levels of Carbon Dioxide

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Growing plant tissue cultures under specific light quality treatments (e.g., white, red, blue, yellow, or orange light) has been conducted to study altered morphogenesis. Characteristic differences in leaf shape, rooting, axillary shooting and fresh weights may be obtained depending on the light quality treatments employed. However, light quality treatments also results in a reduction of available light intensity provided to the culture which can be detrimental. Long-term treatments (i.e., 8 weeks) with certain light treatments may result in severe stunting in growth or even culture death. This situation can be corrected by increasing the light intensity for each light quality treatment employed or reducing the time

of treatment exposure. As an alternative, this study was conducted to determine if coupling colored light treatments with enhanced ultra-high CO₂ levels (e.g., 10,000 L·liter⁻¹ CO₂) could result in growth rates comparable to that occurring in white light treatments. The growth results of employing several species (i.e. lettuce, thyme, citrus) shoot cultures under various light quality treatments with and without ultra-high CO₂ levels are presented. Ultra-high CO₂ levels enhanced culture growth regardless of the light treatment employed. In some cases, cultures that were given ultra-high CO₂ levels with several light treatments exhibited growth rates that exceeded that obtained from white light treatments. Based on these results, ultra-high CO₂ levels may play a role in testing and obtaining a beneficial effect from light quality treatments on plant tissue cultures.

71 ORAL SESSION 14 (Abstr. 420–424) Floriculture—Molecular Biology

420

Variability of Clonal Selections of Poinsettia 'Eckespoint Monet'

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The introduction of poinsettia (*Euphorbia pulcherrima*) cultivar Eckespoint Monet in 1994 provided a novelty bract color that promised to be a welcome addition to the array of poinsettia colors available. The light tan bracts of 'Monet' are splashed with flecks of medium rose, with the flecks concentrated on the margins. In warm growing areas, the bracts' base color appears faded and the rose flecks are not intense, which delays time to market and reduces consumer acceptance. Plants with darker rose flecks were observed in 1994 and clonal selections were saved that had a range of very light to very dark rose flecks. Further selections within these clones were made in 1995 based on bract color and consistency. A cultivar trial in 1996 evaluated 26 of these clones compared to the true 'Monet' and a 'Dark Monet' from the Ecke Ranch. Single plants were grown in 20-cm containers and pruned twice. Data were recorded on plant height and diameter, days to first bract color, marketable, and anthesis, the percentage of mutant laterals, and bract color. Plant height and diameter and days to anthesis were not significantly different among the selections but the clones with darker bracts were marketable up to 5 days earlier than 'Monet'. Selections with darkest rose flecks occasionally mutated to solid red but these laterals could be easily rogued in propagation beds by using the dark red petioles as a selection criterion. These selections can be too dark when grown in cool climatic areas but are more intense and acceptable in warm regions of the United States.

421

Changes in Responsiveness to Ethylene at the Molecular Level during Carnation Petal Development

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Differences in responsiveness and sensitivity to plant hormones between tissues and in specific tissues during development have been observed. Increased sensitivity to ethylene during development has been demonstrated in fruits and flowers. In order to study the molecular changes in responsiveness to ethylene during flower development carnation petals of three developmental stages were treated with 0.1, 1, 10, 100, or 1000 ppm of ethylene for 0, 0.5, 1, 3, 6, 9, 15, or 24 h. Northern blot analysis was performed on total RNA extracted from these treatments. Hybridizations were carried out with the senescence related cDNAs SR5, SR8, SR12, DCAC01, DCACS1, and DCCP. The respective transcripts showed distinct patterns of accumulation in response to ethylene. SR5 transcripts, encoding for a putative β -glucosidase, accumulated significantly faster and at lower ethylene concentrations than all the other transcripts. DCACS1, an ACC synthase, on the other hand showed a delay in the accumulation of its mRNA when compared to the other genes. As the petals develop each mRNA also showed a unique pattern of increased responsiveness to ethylene. This increase in responsiveness is expressed as a decrease in the ethylene-time constant. The ethylene-time concept, similar to degree-days, states that it takes a certain time for a given ethylene concentration to induce a response, 50% maximum transcript

level in this study. This allows for a quantitative assessment of changes in ethylene responsiveness during petal development.

422

Biological Control of Bacterial Blight of Geranium with H-Mutant Bacteriophages

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Bacterial blight, caused by *Xanthomonas campestris* pv. *pelargonii* (XCP), is considered the most serious disease of geraniums (*Pelargonium x hortorum*). A novel approach that uses bacteriophages (phages, viruses that kill bacteria) for the biological control of geranium blight will be presented. Phages were once abandoned as biological control agents due to the emergence of bacterial mutants resistant to the phages employed. However, our approach utilizes a mixture of three to eight different phages including host-range mutants (H-mutants). H-mutants are spontaneously derived from their wild-type parent phages and lyse not only parent wild-type bacteria, but also phage-resistant mutants originating from parent bacteria. Two phages specific for XCP initially were isolated from soil samples from Florida and California. These phages produced virulent reactions in six of 30 XCP strains, and lysogenic reactions in 22 strains. After selection of these phages for increased virulence and additional phages were isolated from MN and UT, 17 phages were evaluated for sensitivity to 21 XCP strains from around the world. Four to 14 phages produced virulent reactions in the 21 XCP strains. Five phages produced virulent reactions in at least 17 XCP strains. A mixture of five phages tested against the 21 XCP strains produced virulent reactions for all 21 XCP strains. Geraniums in 10-cm pots were inoculated with XCP and placed on a greenhouse bench in the middle of 5 non-inoculated plants. After 2 weeks of daily spraying plants with a phage solution (109 pfu phage/ml) or water, there was a 71% reduction in the number of bacterial lesions on phage-treated plants.

423

Effects of an Autoregulatory Senescence-inhibitor Gene Construct on *Nicotiana glauca* Link and Otto.

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Nicotiana glauca Link and Otto. was transformed via *Agrobacterium tumefaciens* encoding a senescence-specific promoter SAG12 cloned from *Arabidopsis thaliana* fused to a *Agrobacterium tumefaciens* gene encoding isopentenyl transferase (IPT) that catalyzes cytokinin synthesis. This was considered an autoregulatory senescence-inhibitor system. In 1996, we reported delayed senescence of intact flowers by 2 to 6 d and delayed leaf senescence of transgenic vs. wild-type *N. glauca*. Further evaluations in 1997 revealed several other interesting effects of the SAG12-IPT gene construct. Measurement of chlorophyll content of mature leaves showed higher levels of both chlorophyll *a* and *b* in transgenic material under normal fertilization and truncated fertilization regimes. At 4 to 5 months of age transgenic plants expressed differences in plant height, branching, and dry weight. Plant height was reduced by 3 to 13 cm; branch counts increased 2 to 3 fold; and shoot dry weight increased up to 11 g over wild-type *N. glauca*. These observations indicate the system is not tightly autoregulated and may prove useful to the floriculture industry for producing compact and more floriferous plants.

424

The Effect of a pH Gene on the Color of *Petunia* Flowers

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An in vivo system was developed to determine the effects of pH on naturally occurring, pigment complexes within cells. The in vivo system was based upon a controlling element inserted into the *Ph6* gene. The controlling element mutation was crossed into a genetically marked *Petunia* line expressing known flavonoid pigments. Flowers expressing the controlling element were variegated with the mutant background lighter in color than the revertant sectors. In the progeny, several individuals were found that had sectors that were a different flower color than the background. In these flowers, the background had a higher pH than the sectors. An increase in pH less than 0.5 unit changed the color from red to blue.

77 ORAL SESSION 15 (Abstr. 425–430) Subtropical/Tropical Fruits—Postharvest

425

The Influence of Gibberellic Acid (GA) on Postharvest Pitting of Citrus

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Postharvest pitting is a citrus peel disorder that is characterized by the physiological breakdown of oil glands and is caused by high temperature storage waxed fruit. Pitting can be controlled by low temperature storage (>10 °C) or application of waxes with high gas permeability. However, refrigeration is costly and often difficult to implement while waxes with higher gas permeabilities have gloss values that are considered to be insufficient for consumer acceptance. Consequently, packers would like to control or predict pitting incidence prior to postharvest stress. Pitting incidence within a grove can vary dramatically within a season despite comparable postharvest handling. Thus, peel susceptibility may be not only variable, but alterable. Peel physiology is readily altered by early-season application of GA, a method currently used to retard peel maturation. Since the influence of GA on postharvest pitting is not known, we examined the effect of early-season foliar-applications of GA on peel quality of 'Fallglo' tangerines and white grapefruit. Fruit were harvested throughout the season, washed, coated with shellac-based wax, and stored at 21 °C and 93% RH. GA applied with a silicone surfactant retarded peel maturation as indicated by greener, firmer peels. Pitting incidence was typically less for GA-treated fruit during the initial days of storage. However, GA suppression of pitting did not always persist throughout storage. GA did not affect internal levels of O₂, CO₂, ethanol, or acetaldehyde or weight loss. While the effectiveness of GA was not consistent, the results suggest that GA application strategies could be developed to suppress pitting. Also, GA treatments may help define factors that determine fruit susceptibility to postharvest pitting.

426

Navel Orange Pitting Stimulated by Waxing and High Storage Temperature

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Navel oranges are reportedly susceptible to postharvest peel disorders, including chilling injury and aging/stem end rind breakdown. These and other physiological disorders are sometimes given the common term "navel rind breakdown." California citrus industry reports on recent incidences of navel rind breakdown suggested that some instances of this disorder were similar to "postharvest pitting," a disorder that we have observed in a number of Florida citrus varieties. Thus, we decided to define the morphology and etiology of pitting of 'Washington' navel orange (*Citrus sinensis* L.) peel. The disorder was characterized by the collapse of clusters of oil glands and was stimulated by wax application and high temperature (≥ 13 °C) storage. Internal ethanol levels of waxed fruit stored at high temperature (13 or 21 °C) were significantly higher among fruit that developed pitting than those that did not. The pitting observed in these studies is comparable to previously observed navel orange disorders that have occurred without known cause. Navel orange pitting is morphologically and etiologically distinct from chilling injury and aging/stem end rind breakdown, but is similar to postharvest pitting of Florida citrus fruit.

427

Postharvest Quality of 'Valencia' and Navel Oranges after High Temperature Forced-air Treatments

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'Valencia' and navel orange (*C. sinensis* L. Osbeck) fruit quality was evaluated

following exposure to either a cold treatment (21 days below 2.2 °C) or a high-temperature forced-air (HTFA) treatment (ramped: fruit center end point, 47.2 °C; and constant: 46 °C for 310 min). These treatments are approved as disinfection measures against selected fruit flies (APHIS, 1996). Fruits were stored at either 5 or 1 °C (cold treatment) for 14 days followed by 10 days at 11 °C and 7 days at 20 °C. Fruits were obtained six times during the commercial 'Valencia' and navel orange season (three grower lots/time). Fruits exposed to HTFA (ramped and constant) treatments had significantly lower appearance ratings, total soluble solids, titratable acidity as compared to control or cold treated fruits. Cold treated fruits had significantly higher L* values. Fruits were also presented to an untrained sensory evaluation panel. Both ramped and constant temperature treated fruits were rated significantly inferior in taste. Although statistically significant, these differences were slight. This research demonstrates the potential deleterious quality attributes of 'Valencia' and navel oranges due to HTFA; however, we believe that cold treatment may be the efficacious quarantine treatment method for distant export market. The potential for HTFA treatments for CA citrus, in light of these results is discussed.

428

Hydrothermic Treatment Effects on Some Ripening Changes on Mango Fruits (*Mangifera indica* L) 'Criollo de Bocado' during Storage: I. Physical Parameters

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Mango fruits 'Criollo de Bocado' harvested at the mature-green stage were treated with a hydrothermic treatment of 55 °C for 3 min and stored for 20 days to temperatures of 10 ± 2, 15 ± 2, and 28 ± 2 °C. A randomized design 2 x 3 x 4 with three replications was used. Physical parameters such as color (L*, a*, b*), firmness, and fresh weight loss were studied. Results reported that mango fruits stored at 10.2 and 15.2 °C showed the highest firmness values. Skin color changed very fast during the first storage days, while pulp color required more time to achieve mature ripe color. Fresh weight loss tended to increase with storage time and with high storage temperature. The lowest storage temperature retarded softening in mango fruits and firmness reached the highest values.

429

Hydrothermic Treatment Effects on Some Ripening Changes on Mango Fruits (*Mangifera indica* L) 'Criollo de Bocado' during Storage: II. Chemical Parameters

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Mango fruits 'Criollo de Bocado' harvested at the mature-green stage were treated with a hydrothermic treatment of 55 °C for 3 min and stored for 20 days at temperatures of 10 ± 2, 15 ± 2 and 28 ± 2 °C. A randomized design 2 x 3 x 4 with three replications was used. Some chemical parameters were analyzed, such as total soluble solids content (% TSS), pH, titratable acidity, and TSS/tritatable acidity ratio. TSS content increased with storage time at low temperature. The pH increased measurably with storage temperature, while titratable acidity values results had inconsistent data.

430

Purification and Characterization of 5'-Deoxy-5'-methylthioadenosine Nucleoside from Avocado Fruits

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The polyamine and ethylene biosynthetic pathways utilize methionine as substrate for their biosynthesis. However, methionine pool in fruits and other plant tissues is very limited and is not sufficient to accommodate the amount of ethylene or polyamines that are synthesized during development and senescence. To compensate for the insufficient amount of methionine, plant tissues have evolved a mechanism to salvage 5'-deoxy-5'-methylthioadenosine (MTA), a by-product of polyamine and ethylene biosynthesis, back into methionine. The first enzyme involved in this salvage pathway is MTA nucleosidase. Purification of MTA nucleosidase from mature avocado fruits showed that there are two isozymes of MTA nucleosidase. In this study we will report on the purification of one of the isozymes, MTA nucleosidase I. Using ammonium sulfate fractionation, DEAE-

Sephadex G-100 gel filtration, and hydroxyapatite chromatography, the isozyme was purified 3712-fold yielding about 11% protein. The isozyme migrated as a single band of 40 kDa molecular weight on SDS-polyacrylamide gel electrophoresis. MTA nucleosidase I exhibited an optimum pH of 7.2 and optimum temperature of 55 °C. The K_m value of the isozyme for its substrate MTA is 7.69 μM and the V_{max} is $58.82 \times 10^{-6} \mu\text{mol} \cdot \text{min}^{-1}$. Incubation of MTA nucleosidase I with analogs of MTA, 2.5 mM ethylthioadenosine and 2.5 mM 5'-S-isobutyl-5'-deoxyadenosine, completely blocked its activity. The isozyme activity was also inhibited by putrescine, spermidine, and spermine.

86 ORAL SESSION 16 (Abstr. 431–435) Woody Ornamentals/Landscape/Turf— Crop Production

431

Evaluation of Square Funnel Containers for Container Nursery Production

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A series of experiments was conducted to evaluate the influence of square funnel and round containers on overhead irrigation water collection. Square funnel containers, constructed by attaching a 30.5-cm square plastic extruded funnel surface to the 15.9-cm opening of a conventional round 3-L container, were placed edge-to-edge on a white gravel surface. Conventional round containers were spaced on 30-cm centers. Both container types contained a 2 pine bark: 1 Canadian peat: 1 sand substrate (by volume) in which temperatures were monitored daily at 1600 HR in the center of substrate. Temperatures during August for funnel and conventional containers averaged 34 and 41 °C, respectively. In another experiment, both container types received overhead irrigation either without plants or with small or large (3853 cm² or 5187 cm² leaf area, respectively) *Viburnum odoratissimum* Ker-Gawl. Square funnel containers without plants collected 4.3 times more water than conventional containers; whereas, with plants 1.3 times more water was collected by square funnel containers. Volume of water collected in square funnel and conventional containers with plants was not different due to plant size. Additional information on NO₃-N leaching as influenced by water collection and substrate temperature will be presented.

432

Irrigation Management Practices in Ohio

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Expanding urbanization in Ohio has made the availability of quality water an emerging issue of great importance to the state's nursery industry. This development necessitates an examination of nurseries' use and management of water. This study surveyed 600 Ohio nursery growers with a mail questionnaire to determine the frequency of irrigation and water-saving techniques across the state. The 21-question questionnaire covered topics including water sources, irrigation practices, water testing and information needs. The mailing list used was the Ohio Dept. of Agriculture's licensed nursery operators list. Nonrespondents received a postcard reminder and a second copy of the survey within 3 months of the initial mailing, yielding a 45% response rate. Data was analyzed using SPSS software. Responses indicate approximately 57% of Ohio nurseries used irrigation in the 1997 growing season. For field production, 64% of nurseries used overhead irrigation for at least half of their irrigated production; for container production, 91%. Nearly 41% of respondents using irrigation reported capturing runoff for reuse this past year. The most common irrigation sources for Ohio nurseries were wells (79%) and ponds (62%). Additional goals for the project include raising awareness of water management and water quality issues, identify common water quality problems, and to obtain direction for future research and extension efforts.

433

Effect of Weed Control Methods Upon Soil Physical Properties and Plant Growth

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There has been speculation in trade journals that landscape fabrics, while doing an excellent job of weed control, may have a detrimental effect upon growth of landscape plants. A study is in progress to investigate the manner in which applied landscape fabric affects soil aeration, soil temperature, and water infiltration rate over a period of 18 months. The experimental design is a split-plot with main plots specified as composted or non-composted areas. Within each main plot, the design is a randomized complete-block with four blocks and four treatments per block (control, bark mulch, landscape fabric, landscape fabric + bark mulch). Each plot has been planted with herbaceous species so as to allow analysis of treatment effects upon plant growth. Redox potential is recorded weekly as a measure of soil oxygen status. Infiltration rate is measured biweekly, and soil temperatures within plots are monitored on a continuous basis. Preliminary results suggest that landscape fabrics limit oxygen exchange and that this may adversely affect plant growth. As the study progresses, an attempt will be made to contrast any adverse effects of landscape fabric with the obvious benefits offered by increased weed control.

434

Pre-plant Solarization Affects Bedding Plant Quality and Fresh Weight

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A solarization study was initiated in Central West Florida whereby field plots, comprised of Eau Gallie fine sand known to be infested with *Rhizoctonia solani* and phytoparasitic nematodes, were covered with a double layer of 1.0-mil clear, low-density polyethylene mulch. The split-plot design consisted of 10 plots, five which were solarized for 6 weeks and five left untreated. Each plot was further subdivided into four 1.5 x 1.5-m subplots. On 14 Oct. 1997, 16 *Impatiens wallerana* 'Accent Burgundy' were planted to each subplot. Pre- and post-plant drench treatments included the fungicide, fludioxonil; two biological control agents; and an untreated control. Individual plants and whole subplots were rated for stunting, chlorosis, and incidence of disease from *R. solani* (stem lesions, crown and shoot blight) twice weekly. Two months after planting, plant fresh weight by subplot was measured, plant quality was determined, roots and crowns were plated on selective media and visually evaluated for disease and root-knot nematode symptoms. Soil cores were taken prior to solarization, at planting, and at termination of the study for nematode identification and enumeration. Data presented will be limited to the combined plant fresh weights of subplots and to plant quality; disease symptoms were incorporated in quality ratings. Solarized plots had a 250% greater combined fresh weight than non-solarized plots. The lowest mean quality ratings for any subplot treatment within the solarized plots was significantly greater than the highest ratings of plants from any subplot treatment within the non-solarized treatment.

435

Low-maintenance Alternative Turfgrass

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Thirteen materials and two controls were evaluated for 3 years at two locations for color, cover, and overall rating as acceptable turf or lawn. 10' x 16' plots were maintained at 2", 4", and no mowings; two, one or no fall fertilizations; with no pesticide or irrigation. Best color ratings were the fine fescues; best cover a traditional mix of Kentucky bluegrass, fine fescues and perennial ryegrass (Sunnylawn mix); dryland ecology mix and fleur de lawn; best overall rating was Sunnylawn mix, fine fescue blend, and Ram I. Materials evaluated included: 378 and 45-3 buffalograss; 'Alma' bluegrama; 'No Mow'; 'Azay' sheep fescue; 'Discovery' hard fescue; dwarf sheep fescue; fine fescue blend; fleur de lawn; Dryland Ecology Mix; native grass and forb mix; Flowers and Flowers Elite; Super Short Mix; creeping alfalfa; Sunnylawn mix and 'Ram I' KBG were used as controls.

87 ORAL SESSION 17 (Abstr. 436–443) Floriculture—Growth Regulators/Nutrition/Irrigation

436

Effects of Plant Growth Retardants and Application Timing after Shearing on Growth and Flowering of *Coreopsis verticillata* 'Moonbeam'

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Coreopsis verticillata 'Moonbeam' is a herbaceous perennial that may grow too tall in small containers under greenhouse conditions for market acceptance, and therefore may benefit from plant growth retardants. Rooted terminal cuttings produced under short days were given a terminal pinch and transplanted to 10-cm pots. Cuttings were sheared to 6 cm above the pot rim 4 weeks later. Growth retardant treatments consisting of ancymidol drench at 0, 0.125, 0.25, or 0.375 mg a.i./pot; paclobutrazol drench at 0, 0.125, 0.25, or 0.375 mg a.i./pot; daminozide spray at 0, 2550, 5100, or 7650 mg·L⁻¹; paclobutrazol spray at 0, 12, 24, 36, 48, or 60 mg·L⁻¹; or flurprimidol spray at 0, 25, 50, 75, 100, 150, or 200 mg·L⁻¹ were applied 10 days after shearing. Night-breaking lighting using incandescent bulbs was started the same day. The highest rate of ancymidol, paclobutrazol drench, daminozide, and flurprimidol decreased plant height compared to controls by 36, 30, 21, and 36%, respectively. Paclobutrazol sprays were not effective. A market quality rating of four or higher (good, salable) was given to plants treated with daminozide at 5100 or 7650 mg·L⁻¹ or flurprimidol at 150 or 200 mg·L⁻¹. A second experiment was conducted to determine application timing. A daminozide spray at 0, 2550, 5100, or 7650 mg·L⁻¹ was applied 0, 3, 6, 9, 12, or 15 days after shearing. Plant height, growth index and lateral shoot length were least and market quality rating highest when 5100 or 7650 mg·L⁻¹ of daminozide was applied between 6 and 9 days after shearing.

437

Chemical Growth Retardant Application to *Scaevola*

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Fan flower (*Scaevola aemula* L.) has become a popular specialty bedding and hanging basket plant in the United States. The genus contains several species from Australia and the Indo-Pacific region and there exists a wide diversity of growth habits and flower colors, including blue, violet, pink and white. Our objective was to measure the effect of type of growth retardant, method of application, and chemical concentration on *S. aemula* 'New Wonder', 'Mini Pink Fan', 'Purple Fan', and 'Royal Fan', *S. albida* 'White Fan', and *S. striata* 'Colonial Fan'. Variables measured included days to flower, plant width, flower stem number, flower stem length, and flower number per stem. Uniconazole applied as a media drench to *S. aemula* 'New Wonder' at 1.0 and 2.0 mg·L⁻¹ decreased plant width and flower stem length without affecting time to flower or flower number. Therefore, number of flowers per cm of stem length on *S. aemula* 'New Wonder' was increased, resulting in attractive, compact clusters of flowers on pendulous stems. Paclobutrazol drench (4.0 and 8.0 mg·L⁻¹) was also effective. Daminozide spray (5000 mg·L⁻¹) reduced plant width but flower number was reduced. Ancymidol foliar sprays and media drenches (all rates) had no effect on the parameters measured. Ethephon (500 and 1000 mg·L⁻¹) reduced plant width, but delayed flowering and reduced flower number. Uniconazole drenches were beneficial in improving the quality of *S. aemula*. 'New Wonder' grown in hanging baskets, but the growth control was not long-lived. The effect of uniconazole on plant growth varied with *Scaevola* species and cultivars.

438

Growth Response and Carbohydrate Status of Gibberellin-treated Spectral Filter-grown Chrysanthemum Plants

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Interest in the use of non- (or less) chemical methods to reduce the height of ornamental crops has increased tremendously. Manipulation of greenhouse

light quality is one alternative for plant growth regulation. We have shown that eliminating far-red light from the greenhouse environment with liquid CuSO₄ spectral filters is effective in reducing the height of a wide range of plants though plant carbohydrate status is also altered under CuSO₄ filter. In previous studies, application of GA₃ reversed both the reduction of plant height and carbohydrate status of CuSO₄ spectral filter grown plants. It has been proposed that GAs enhance the activity of the enzyme sucrose phosphate synthase to regulate carbohydrate levels. In the present study the role of exogenously applied GA₁₉, GA₁, and GA₃ in overcoming the reduction of plant height and carbohydrate levels was investigated. Chrysanthemum plants were treated weekly for 4 weeks with saturating doses of GA₁₉, GA₁ and GA₃ (25 µg) or the growth retardants paclobutrazol and prohexadione. GA₁ was also applied with paclobutrazol and prohexadione to assess whether response to GAs is altered under CuSO₄ filter. GA₁ and GA₃ promoted growth similarly under control or CuSO₄ filter. GA₁₉ was least effective in promoting growth under CuSO₄ filter. In summary, these results suggest that gibberellin physiology is altered under spectral filters with the conversion of GA₁₉ a possible point of regulation. The correlation between the carbohydrate status and the growth of the plants will be discussed.

439

Irrigation of Geraniums with an Automatic Controlled Water Table System

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Geraniums in 15-cm pots were irrigated automatically for 8 weeks with a Controlled Water Table (CWT) irrigation system. Plants were irrigated with a nutrient solution supplied by a capillary mat with one end of the mat suspended in a trough below the bottom of the pot. The nutrient solution remained at a constant level in the trough. Nutrient solution removed from the trough was immediately replaced from a larger reservoir. The vertical distance from the surface of the nutrient solution and the bottom of the pot determined the water/air ratio and water potential in the growing media. Treatments consisted of placing pots at 0, 2, 4, and 6 cm above the nutrient solution. Control plants were irrigated as needed with a trickle irrigation system. Geraniums grown at 0, 2 and 4 CWT were ≈25% larger than the control plants and those grown at 6 CWT as measured by dry weight and leaf area. Roots of plants grown at 0 CWT were concentrated in the central area of the root ball; whereas roots of plants in other treatments were located more near the bottom of the pot. Advantages of the CWT system include: Plant controlled automatic irrigation; no run off; optimum water/air ratio.

440

Growth of *Dracaena marginata* and *Spathiphyllum* 'Petite' in Sphagnum Peat and Coconut Coir Dust-based Growing Media

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Dracaena marginata Lam. and *Spathiphyllum* 'Petite' were grown in three greenhouse growing media made with Philippine coconut (*Cocos nucifera* L.) coir dust (CD) or Canadian sphagnum peat (SP). Three soilless media [Cornell, Hybrid, Univ. of Florida #2 (UF-2)] were prepared using CD or SP and pine bark (PB), vermiculite (V), and/or perlite (P) in the following ratios (percent by volume): Cornell = 50 CD or SP:25 V:25 P; Hybrid = 40 CD or SP:30 V:30 PB; UF-2 = 50 CD or SP:50 PB. When most of the plants of each genus were of marketable size, plant root and top masses and grades were determined as well as plant top growth indices. For dracaena, there were interactions between medium component (CD/SP) and medium type for everything except mass and grades of roots. For Cornell mix, plant top growth index and grades were higher for SP- (SPM) than the CD-containing medium (CDM). However, masses were not different due to component. For Hybrid mix, only top mass was affected (CDM 12% > SPM). For UF-2, top plant index and top and total plant masses were higher for CDM than SPM by 10, 19 and 15%, respectively. Overall, plant masses were the same for all three mixes containing CD; however, top plant index and grades were higher for the Hybrid and UF-2 mixes than for Cornell. Using SP, plants in Cornell and Hybrid mixes generally outperformed those in UF-2. For *Spathiphyllum*, there were no interactions and medium component only affected root ratings (CDM > SPM). Plant top, root and total masses and root ratings were higher for Cornell and Hybrid than for UF-2.

Application of Processed Fiber for Nursery Crop Production

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Composted Tillamook Methane-digested dairy manure (processed fiber) plus woodwaste from landfills at Tillamook, Ore., was compared with Langerwerf, Calif., processed fiber amended with woodwaste from Tillamook, a mixture of peatmoss and pumice, and two commercial mixes from Black Gold Inc., Hubbard, Ore. Electrical conductivity, water-holding capacity, pH, cation exchange capacity, and mineral contents of Tillamook processed fiber with a mixture of wood waste were within the acceptable range for production of some nursery crops. Tillamook processed fiber with a mixture of wood waste media were favorable for the germination and growth of the lettuce and radish cultivars. The performance for seed germination was comparable to the performance of both Black Gold media and better than the other media. The growth of marigold 'Bonanza Yellow', petunia 'Plum Madness', and salvia 'Purple Sizzler' in Tillamook processed fiber wood media, supplemented with weekly feeding of fertilizer, was comparable to their growth in Black Gold media and better than the other media. The growth of 'Double Delight' rose plants in Tillamook processed fiber wood media was similar to their performance in Black Gold media.

442

Phosphorus Fertilization in Ebb and Flow Production of Bedding Plants

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The quantity and quality of available water in the Southeastern United States continues to decline as demands on limited resources increase. Growers will soon be forced to comply with legal limitations on water consumption and limits on nutrient runoff from their operations. A lack of information on standard growing practices using alternative irrigation systems such as ebb and flow is hindering their acceptance and implementation. We are currently conducting a series of experiments to establish basic growing guidelines for the use of ebb and flow in the greenhouse in bedding plant production. In the third of these experiments, *Petunia x hybrida* Hort. Vilm.-Andr. 'Blue Frost' and *Begonia x hiemalis* Fotsch. 'Ambassador Scarlet' were grown for 5 weeks on ebb and flow tables with fertigation solutions (225 ppm N) containing three different levels of phosphorus (0, 50, and 100 ppm). Three soilless media were also used, which varied in their percentage content of vermiculite, perlite, pine bark and coconut coir. For both the begonias and petunias dry mass of the shoot was greatest in plants grown with higher levels of phosphorus. In comparison to plants grown with 0 ppm phosphorus, petunias and begonias grown with 50 or 100 ppm P were 44% and 25% greater in mass, respectively. However, begonias had 38% more flowers when fertigated with the higher levels of phosphorus while petunias flowered earlier with 0 ppm P fertigation solution. The electrical conductivity of the media did not change significantly over the course of the growing period, but the pH dropped by an average of 1 over the same time interval.

443

Nitrogen Demand of Cut Chrysanthemums in Relation to Shoot Height and Planting Date

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Refined nutrient delivery systems are important for environmentally friendly production of cut flowers in both soil and hydroponic culture. They have to be closely orientated at the actual nutrient demand. To solve current problems, express analysis and nutrient uptake models have been developed in horticulture. However, the necessity of relatively laborious analysis or estimation of model input parameters have prevented their commercial use up to now. For this reason, we studied relationships between easily determinable parameters of plant biomass structure as shoot height, plant density and dry matter production as well as amount of nitrogen removal of hydroponically grown year-round cut chrysanthemums. In four experiments (planting dates 5.11.91; 25.3.92; 4.1.93; 1.7.93) with cultivar 'Puma white' and a fixed plant density of 64 m², shoots were harvested every 14 days from planting until flowering, with dry matter, internal N concentration and shoot height being measured. For each planting date, N uptake (y) was closely ($r^2 = 0.94; 0.93; 0.84; 0.93$, respectively) related to shoot height (x) at the time

of cutting and could be characterized by the equation $y = a * x^b$. In the soilless cultivation system, dry matter concentrations of N remained constant over the whole growing period, indicating non-limiting nitrogen supply. In agreement with constant internal N concentrations, N uptake was linearly related ($r^2 = 0.94$ to 0.99) to dry matter accumulation. It is concluded that shoot height is a useful parameter to include in a simple model of N uptake. However, in consideration of fluctuating greenhouse climate conditions needs more sophisticated approaches including processes such as water uptake and photosynthetically active radiation.

88 ORAL SESSION 18 (Abstr. 444–451) Vegetable Crops—Culture & Management (Sustainable Agriculture)

444

Impact of Narrow Row Production on Yield Recovery, Nitrogen Use Efficiency, and Weed Competition in Sweet Corn

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The processing industry is beginning to adopt narrow row configurations for sweet corn production thinking that plants spaced more equidistant will compete less with each other and weeds, improving yield potential and production efficiency. However, empirical knowledge relating to whether these proposed benefits change with hybrid, N fertility, and planting date is lacking. Narrow row (56 cm apart) sweet corn production was evaluated for improved production efficiency over the "traditional" row configuration (76 cm apart) at identical plant populations (60,000/ha). Yield from seed planted in narrow rows on 1 May was significantly higher than traditional row configuration. Increasing N fertilizer rate (0, 68, 136 kg N/ha) also yielded a positive linear response in yield across the three hybrids. As planting date progressed later into the season (27 May and 19 June), narrow row configuration benefits observed earlier began to diminish. Although increased N fertilizer rates continued to show a positive yield response across all planting dates, the degree of the slope decreased as planting date was progressively delayed suggesting a greater rate of N mineralization from the soil. Plant leaf samples were collected from each plot at silking for N analysis and determination of N use efficiency. Degree of canopy closure was dependent on plant architecture of the hybrid and N fertilizer rate; and may be related to postemergence weed competition and yield potential. The decision to convert to narrow row production would require a significant capital investment in new equipment. An economic assessment of the equipment required in addition to more detailed information on yield response to the narrow row configuration will help the processor make an informed choice when considering conversion.

445

Evaluation of Tillage Methods and Cover Crops for Sweetpotato Production

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The marketable yield of the sweetpotato [*Ipomoea batatas* (L.) Lam.] can be limited by environmental variation. Cover crops may ameliorate water and temperature stress encountered during the growing season while reducing soil erosion and weed competition. The objective of this research was to investigate the commercial production of sweetpotatoes with cover crops in a conventional or conservation tillage system. Rye, ryegrass, wheat, and triticale were broadcast-seeded in Fall 1995 and 1996. Three weeks before transplanting, the cover crops were plowed-in or retained as an in situ mulch. Uniform slips of 'Beauregard' sweetpotato were transplanted in May and June of each year, and standard cultural practices (with the exception of cultivation) were performed. In 1996 and 1997, conservation tillage increased marketable yield of sweetpotato 15% with a noticeable improvement in quality. Ryegrass produced the largest quantity of biomass and was effective in reducing soil temperature during storage root initiation and development. Conservation tillage resulted in a significantly higher root set relative to the control. Conservation tillage seems to have advantages as an alternative tillage method for sweetpotato production.

Swine Effluent for Tomato in a Plasticulture Production System

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Tomato was grown in Fall 1997 with swine effluent or commercial soluble fertilizer in a plasticulture production system. Four cultivars, 'Mountain Delight', 'Celebrity', 'Equinox', and 'Sunbeam', were transplanted to raised beds with plastic mulch and drip irrigation. Preplant fertilizer was not applied. Effluent from the Wiley L. Bean Swine Demonstration Unit's secondary lagoon was filtered through in-line screen filters and applied directly to the plants through the irrigation system. Toward the end of each application, sodium hypochlorite was injected in the line to achieve a free chlorine concentration of $\approx 1\%$. Clogging of filters or drip emitters did not occur. Control plants received 100 ppm N from soluble fertilizer injected in irrigation lines supplied by a municipal water source. Number and weight of tomatoes from plants receiving swine effluent were equal to that of plants receiving soluble fertilizer. No differences in fruit quality were evident between treatments. Plant dry weight was also equal for three out of four cultivars. No differences in soil characteristics were detected between treatments after the study. Chemical analysis of the effluent showed a pH of 7.8 and nutrient concentrations of ≈ 110 ppm $\text{NH}_4\text{-N}$, 57 ppm P_2O_5 , 150 ppm K_2O , and trace amounts of Cu and Zn. Though no differences in yield were detected in this study, the effluent's high pH and high $\text{NH}_4\text{-N}$ content need to be managed more closely for commercial tomato production.

447

Effect of Compost Applications on the Yield of Several Vegetables in Long-term Organic Farming Experiments Conducted in the Tropics

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Experiments conducted over 5 years evaluated the effect of compost applications on the yield of several vegetable crops grown under organic farming conditions in the tropics. The yield of organically grown lettuce, basil, Filipino spinach (*Corchorus olitorius* L.), and zucchini after application of 20 MT compost/ha per crop was compared to yields obtained with standard synthetic fertilizer applications (150 kg N/ha per crop), and with a combination of several compost : synthetic fertilizer ratios. Treatments consisted of 10 by 1.30-meter raised beds replicated four times. Data collected included soil nutrient analysis prior to planting and after the last harvest, tissue analysis of macro- and micronutrients, canopy dimensions, and yields. The tissue nutrient levels collected from crops receiving composts alone were at or above those levels recommended to achieve commercially acceptable yields. Yields of plants receiving composts alone were comparable to those obtained by plants receiving synthetic fertilizer applications. However, the greatest yields were obtained with 20 $\text{MT}\cdot\text{ha}^{-1}$ of compost plus supplemental synthetic N applications, depending on the length of the harvesting period. After 5 years cumulative yields ranged from 110 to 124 $\text{MT}\cdot\text{ha}^{-1}$ for vegetables receiving compost plus supplemental N, compared to 75 for controls, and to about 100 $\text{MT}\cdot\text{ha}^{-1}$ for treatments receiving either synthetic N or compost applications alone.

448

Effect of Poultry Compost on Productivity and Quality of Beets

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One characteristic of compost that might provide greater incentive for use by vegetable growers is suppression of soil-borne diseases in crops grown on compost-amended soils. The mode of action of low rates of compost on vegetable growth may include stimulation of microbial activity for suppression of soil-borne diseases, enhanced plant resistance, and improved nutrient availability. Preliminary research on beets demonstrated that higher stands and decreased loss to root rot diseases in poultry compost-amended plots contributed to marketable yields which were twice that of the control plots. This presentation will summarize research results from studies to determine if compost reduced disease severity by changing in soil microbial activity or if these products primarily improved plant growth as a result of increased nutrient availability. Three field experiments explored

impact of two commercially available poultry compost products (2 to 5 T/A) and two rates of chemical fertilizer, on growth and disease incidence on beets. Soil microbial activity was estimated using an enzyme assay, and soil nitrate-N and ammonium-N concentrations were also measured, three times over the season. Results indicated that these composts act primarily through a nutrient affect to enhance beet yield. Neither compost affected microbial activity in the top 8 inches of soil. Both products had significant, opposite effects on available soil nitrogen. One product significantly increased the amount of available soil nitrogen over the season and beet yields. The different methods of production of the two poultry composts tested in this research had significant implications for potential use in either greenhouse or field systems. The effects of these composts on crop fertility and composition will be discussed.

449

Tomato Growth and Yield Response to Cover Crop and Fertilizer Nitrogen

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The goal of this study was to evaluate how tomato yield, vegetative dry matter, leaf area index (LAI), and photosynthesis (P_n) responded to winter cover crop and recommended fertilizer N rates. The following winter/spring fertility treatments were applied using randomized complete block design with four replications: 1) 0 N winter /0 N spring, 2) 0 N winter/90 $\text{kg}\cdot\text{ha}^{-1}$ N spring, 3) 0 N winter/180 $\text{kg}\cdot\text{ha}^{-1}$ N spring, 4) 0 N winter + abruzi rye/0 N spring, 5) 0 N winter + hairy vetch/0 N spring, and 6) 0 N winter + crimson clover/0 N spring. In Spring 1997, 'Mountain Pride' tomatoes were transplanted in all plots. Whole plant dry matter, LAI and P_n were measured at flowering, fruiting and prior to senescence, while seasonal yield was compiled over 6 weeks. Tomatoes preceded by Vetch produced highest plant dry matter (243.0 g/plant) prior to senescence, highest LAI (3.07) at fruiting and highest P_n (8.98 $\mu\text{mol CO}_2/\text{m}^2$ per s) during flowering. Total yield were highest (60.9 $\text{Mg}\cdot\text{ha}^{-1}$) at 180 $\text{kg}\cdot\text{ha}^{-1}$ N and lowest (35.3 $\text{Mg}\cdot\text{ha}^{-1}$) in control. Supplemental N from legume and grain cover crops affected plant dry weight, LAI, P_n , and yield comparable to those receiving synthetic N. Results of this study indicate that cover crop treatments were as effective as N fertilizer in supporting tomato yield, vegetative growth, LAI, and photosynthesis.

450

Evaluation of Summer Cover Crops for Vegetable Production in South Florida

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Cover crops are used for weed control and to retain nutrients during the heavy summer rains and have become an integral part of vegetable production practices in south Florida. Moreover the use of cover crops will continue to increase as farmers seek to improve soil quality and reduce chemical inputs. A wide variety of plants are used as cover crops in south Florida. Obviously legumes contribute more nitrogen by fixing N compared to nonlegumes such as sorghum-Sudan grass, which is a common cover crop in this area. We have evaluated 10 cover crops, and five of them are legumes. The sunn hemp, *Crotalaria juncea* L., stands out from other tested cover crops. Sunn hemp produced 8960 kg dry weight per ha and fixed up to 336 kg N/ha. We have strongly recommended sunn hemp as a cover crop for vegetables and tropical fruits in south Florida. A large field demonstration will be conducted in a grower's field in the summer rainy season of 1998.

451

Living Mulch Strips as Habitats for Beneficial Insects in the Production of Cucurbits

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Effects of cover crops managed as living mulch habitats on populations of cucumber beetles *Acalymma vittatum* Fabricius and *Diabrotica undecimpunctata* howardi (Barber) (Coleoptera: Chrysomelidae) and arthropod predators were assessed at the Virginia Tech Kentland experimental farm and a local farmer's field in 1994 and 1995. In 1994, spring-planted strips of two living mulch mixtures, oats/vetch (*Arvena sativa/Vicia atropurpurea*) and oats/white clover (*A. sativa/Trifolium repens*), and straw mulch between rows of cucumber cv. Pointsett and an heirloom pumpkin cultivar were compared to non-mulched plots in a random-

ized complete-block design. Counts of the predator Pennsylvania leatherwing, *Chauliognathus pennsylvanicus* (Coleoptera: Cantharidae) on yellow sticky traps were 2.7 to 10 times greater in living mulch treatments, compared to plots with cucurbits alone or with straw mulch ($P = 0.0040$ in 1994 and $P = 0.0085$ in 1995). In 1995, counts of *Harpalus* spp. (Coleoptera: Carabidae) in buckwheat *Fagopyrum esculentum* (Moench) living mulch treatments were twice those in the plots with the crop alone, and cucumber beetle counts were 60% lower ($P = 0.0165$) in the mulched habitats. Crop yields were depressed in living mulch treatments, but a twin-row planting system (5:3 crop: habitat ratio) with buckwheat gave yields 4.8 times greater than the single-row system (3:5 crop: habitat ratio) initially used in 1994. These yields were 72% of yields in the control using conventional practices. These results indicate that strip cropping has the potential to maintain cucumber beetle populations below threshold levels, but that more management research is needed to obtain economically viable yields.

99 ORAL SESSION 19 (Abstr. 452–458) Vegetable Crops—Crop Protection/Pest Management

452

Yield of 'Superior' Potatoes following Nematode-suppressive Cover Crops

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'Superior', the common early potato in Ontario, has developed early dying and low yield problems along the Lake Erie Counties. A series of experiments were planted in 1993 to 1996 to evaluate nematode-suppressive cover crops as a means of soil management, improving yield of potatoes, and reduction of plant parasitic nematodes. Sorghum NK557 as a nematode host, reported suppressive species Sordan 79, Trudan 8 sorghum-sudan hybrids, Domo and Cutlass mustard, Forge canola, and 'Norlee' flax were compared to either Telone IIB or Vortex-Cp (225 L/ha) fumigants applied with a deep shank applicator to 30 cm. Fertility and pest management practices followed Ontario recommendations. Northern root lesion nematodes, *Pratylenchus penetrans* Cobb, populations were monitored prior to planting potatoes, during the season, and after harvest. Fumigation resulted in the highest total yields in all 3 years and marketable yield in 1994 and 1995. There was no difference in marketable yield in 1996. Yield was similar among cover crops treatments. Suppressives crops, while useful in soil management, were not as effective as fumigants.

453

Metam Sodium Combined with Chloropicrin as an Alternative to Methyl Bromide Fumigation for Tomato

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In past work, dichloropropene + 17% Pic (1,3-D + Pic) at 327 L·ha⁻¹ plus pebulate provided good control of nematode, soil fungi, and nutsedge in mulched tomato (*Lycopersicon esculentum* Mill.) and is considered the best alternative for methyl bromide (MBr) + chloropicrin (Pic), which is scheduled for phase-out in the United States by Jan. 2001. Metam-sodium did not provide acceptable pest control. In the present study, metam-Na (295 L·ha⁻¹ combined with Pic (168 kg·ha⁻¹) + 4.5 kg·ha⁻¹ pebulate, and 1,3-D + 35% Pic at 168 and 225 L·ha⁻¹ + pebulate were compared to MBr-Pic (98-2% at 345 kg·ha⁻¹ and 67-33% at 505 kg·ha⁻¹). Fumigants were injected into the bed except metam-Na and pebulate were surface-applied and incorporated and drip tubing and mulch were applied. Marketable yields with MBr-Pic, 225 L·ha⁻¹ 1,3-D + Pic, and metam-Na + Pic were higher than with the check. Yields with metam-Na alone or with additional water before transplanting were similar to the check. Nutsedge was controlled with MBr-Pic and all treatments with pebulate. Nematode root-gall ratings were high on tomato grown without fumigants (8.9 rating on a scale of 0 to 10 with 0 = no galling), low with MBr-Pic (0.33), and intermediate with all other treatments (2.2 to 5.5) except with 168 L·ha⁻¹ 1,3-D + Pic (8.3). This study indicates that metam-Na + Pic + pebulate also is a possible alternative to MBr-Pic for tomato.

454

Use of the Biological Compound Ret-flo Px357 to Increase Yield and Improve Fruit Quality of Tomato and Banana Grown in a Greenhouse

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In the past few years, there has been a high demand for the use of new generations of biological products in modern agriculture. Several of these products are friendly to the environment and guarantee good yield and quality of many horticultural products. Pesticide residues resulting from heavy applications of a wide range of chemicals to control various pests is becoming a serious problem for exports, as well as for local consumption, of many products. This study was initiated to examine the effect of Ret-flo Px-357 a biological compound from EIBOL Co., Spain, developed to induce resistance to nematode infestation on several plants. 'Daniella' tomato and 'Grande naine' banana grown in plastic greenhouses were used to evaluate these effects. Two ground applications of Px357 at the rate of 20 L·ha⁻¹ were used at 4-month intervals in Oct. 1996 and Feb. 1997. These treatments have stimulated root formation, stem diameter, and plant height. In tomato plants, the number of flowers and fruits per cluster was greater in treated than in non-treated plants. After harvesting eight clusters from the tomatoes, the number, size, individual fruit weight and total production of fruits from treated plants were greater than for the control plants. Similar results were observed in banana plants, which showed larger pseudo-stem and heavier fruit bunches at harvest. Variation in nematode population as well as plant nutrition during plant growth will be discussed, and results related to fruit quality will be presented and commented upon.

455

Assessment of Chemical Induction of Acquired Resistance to Pythium Fruit Rot in Field-grown Cucumber

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Systemic acquired resistance (SAR) is a physiological defense response in plants conferring broad spectrum resistance to pathogens. SAR is inducible through infection by necrotizing pathogens or chemical inducers and involves the systemic activation of defense related genes. The objectives of this study were to evaluate resistance expression to *Pythium* soft rot in fruit of cucumber in response to foliar applications of 2,6-dichloro isonicotinic acid (INA), benzo(1,2,3)thiadiazole-7-carbothioic acid S-methyl ester (CGA 245704), or beta-amino-butyric acid (bABA). Excised leaves from three cucumber cultivars, Vlaspiik, Sumpter and SMR 58, exhibited a resistance response to foliar applications of INA (50 ppm) and CGA 245704 (25 ppm) when challenge inoculated with *Colletotrichum lagenarium*. However, the reduction in lesion incidence by INA was 99% in Vlaspiik and only 11% and 18% in Sumpter and SMR 58, respectively. bABA did not enhance resistance in vegetative tissues. Multiple foliar applications of INA and CGA 245704 prior to fruit set were found to be more effective than a single application. Harvested cucumber fruit, 3.0 to 5.0 cm in diameter, were wounded and challenge inoculated with *Pythium* sp.: no statistically significant differences in infection were observed between controls and fruit from chemically treated plots. In Vlaspiik, however, INA and BTH did reduce the rot infection rate in fruit when foliar applications were made early in plant ontogeny, at the four-leaf stage. In addition, larger more mature fruit (4-5 cm diameter) exhibited slower lesion growth than less developed fruit (>3 cm). It is unclear if these differences were attributable to changes in physiological or anatomical factors. These findings indicate that the level of physiological resistance achievable through chemical induction in cucumber is a function of the specific pathogen and the plant organ being infected, i.e., leaves or fruit.

456

Two-cluster Tomatoes Require Less Pesticide per 1000 kg of Salable Fruit than Eight-cluster Tomatoes

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Tomatoes were grown in plastic-covered rainshelters at a cool, moist 1300-m elevation. Plants were placed in aluminum beverage cans filled with growing medium and immersed in a 0.6-m wide tank containing 5 cm of non-circulating nutrient solution. Tomatoes were pruned such that only two, four, or eight clusters were harvested. Two-cluster 'Vendor' tomatoes yielded 49% and 73% more salable tomatoes per day than eight-cluster tomatoes in two experiments,

respectively. Two-cluster 'Lenor' tomatoes yielded 47% and 92% more salable tomatoes per day than eight-cluster tomatoes in two experiments, respectively. Two-cluster tomatoes required 347 g of pesticide to produce 1000 kg of salable fruit compared to 708 g pesticide for eight-cluster tomatoes in the first experiment. Fungal pressure increased in the second tomato experiment such that the two-cluster tomatoes required 1112 g of pesticide to produce 1000 kg of salable fruit, whereas the eight-cluster tomatoes required 2075 g of pesticide. Most of the pesticides applied were fungicides.

457

The Effects of American Black Nightshade (*Solanum americanum*) Interference in Bell Pepper (*Capsicum annuum*)

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Information about the effects of weed interference on crop yields can help growers make appropriate management decisions. Such information is particularly useful in horticultural crops such as pepper, where the number of registered herbicides is limited. Bell pepper is the second most-valuable vegetable crop grown in Florida, and American black nightshade (*Solanum americanum*) is one of the primary weeds in Florida pepper production. Additive experiments were conducted in 1997 in Florida to determine the effects of American black nightshade interference on bell pepper yield. One additive experiment was conducted in Gainesville, Fla., in the spring and two additive studies were conducted in the fall in Gainesville and Live Oak, Fla. A randomized complete-block design with four replications was used. Double rows of 'Capistrano' peppers were transplanted into white polyethylene mulched beds with 1.22-m centers. Peppers were planted at an in-row spacing of 0.3 m. Weeds were propagated in the greenhouse in polystyrene flats and transplanted at the two-leaf stage simultaneously with the peppers. Overhead irrigation was used and monitored with tensiometers. Fertilizers and pesticides were applied based on Extension recommendations. Weed densities in the spring trial were 0, 2, 4, 8, 12, 16, and 20 plants/m². Weed densities of 0, 0.5, 1, 1.5, 2, 3, 4, and 8 plants/m² were planted in the fall. Crop and weed heights were recorded weekly, and fruit number, grade, and weights were recorded at each harvest. Crop and weed dry weights were obtained at final harvest. Data were subjected to analysis of variance and regression. There was an interaction by season, but there was not an interaction by location for the fall season; therefore, the fall data were combined. In all trials, *S. americanum* had a significant effect of bell pepper fruit yield. In the spring, the biological threshold of weed interference occurred at a density of four *S. americanum*/m², but only caused a 50% yield loss. In the spring, the critical density causing 20% yield loss was calculated from the regression model to occur at 0.36 *S. americanum*/m². A calculated density of 0.58 *S. americanum*/m² caused 20% yield loss in the fall. Plant height and dry weight data indicated that the pepper initially grew more quickly in the fall than in the spring.

458

The Effect of Rhizosphere Competence on Colonization of Sweet Corn Roots by Biocontrol Fungi in Differing Soils

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To be effective, biocontrol agents, fungi need to colonize roots under a wide range of conditions. The ability to do so is called rhizosphere competence. A common beneficial fungus, *Trichoderma harzianum*, has been bred to produce a new strain, T-22, that has exceptionally high rhizosphere competence. In field experiments, we have demonstrated that T-22 was resistant to edaphic conditions that reduce colonization by indigenous *Trichoderma* species, so that it can provide protection against root pathogens. Well-drained sand, stone or gravel soils supported lower populations of wild *Trichoderma* than did loams (10^{0.5} vs 10^{3.3} cfu/g), but populations of T-22 were high in all soils (>10⁴ cfu/g). In a multivariate analysis of soil characteristics affecting colonization, only soils with low Ca and low pH had reduced populations. No other measured soil characteristics were correlated with colonization. When sown in the field at different initial soil temperatures ranging from 10 to 27 °C, T-22 populations were unaffected by temperature, having a population from 10^{4.6} to 10^{5.4} cfu/g. Indigenous strains were 10³ in cold soils, peaked at 10⁴ at 15 °C, declining in later sowings due to higher biological competition. Differences in microbial competition had little effect. Roots were equally colonized in the differing soil microflora in three management systems at the Rodale Farming Systems Trial. Invading an existing soil microbial community

is the most difficult thing to achieve with a biocontrol organism. These data show that T-22 is the first to consistently do so.

100 ORAL SESSION 20 (Abstr. 459–464) Nuts—Breeding & Genetics

459

Final Results of Propagation Experiments to Show Distribution of Noninfectious Bud-failure in 'Carmel' Almond

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The distribution of the potential for noninfectious bud-failure (BF_{pot}) was shown for the entire 'Carmel' almond cultivar by propagating from single buds on single budsticks on individual trees of separate source blocks of commercial nurseries. Approximately 2700 progeny trees were grown at the same test site. The gradual increase in the expression of BF (BF_{exp}) in progeny trees from individual source trees shows a continuous range of latent BF_{pot} among individual source trees directly correlated to five (or six) consecutive generations of vegetatively propagated source orchards. This pattern shows a continuous gradient in expression (*vertical variation*). A continuous gradient in expression also exists among progeny trees originating from the same source tree (*horizontal variation*). Individual source trees were identified whose progeny produced little or no BF_{exp} when grown for 5 or more years in a high temperature test site. These studies confirm that *noninfectious bud-failure* (and probably other *genetic disorders*) represent persistent variants of a specific gene(s) whose gene_{pot} changes during vegetative growth sequences to bring about differential expression over time ("age") and developmental patterns. These represent a class of clonal variants which are "age-related" and include "phase changes", "juvility-maturity" phenomena, and can affect morphology, thorniness, ease of rooting, etc. BF is related to a gene that affects environmental adaptation of the almond. Control is through the selection, maintenance and management of *foundation clones*.

460

Endocarp Structural Components of Insect Resistance in Almond

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Almond, as with other stone fruit, possesses a highly lignified endocarp or shell. The dominant hard-shelled trait (D-) is positively associated with greater resistance to insect infestation than nuts expressing the paper-shelled (dd) trait. Hard-shelled genotypes have undesirable effects, including a lower kernel meat-to-nut crack-out ratio, greater kernel damage during mechanical shelling, and a reduction in plant energy available to kernel development. Histogenic analysis shows that the almond endocarp, unlike peach, has a tri-partite structure. Insect feeding studies have subsequently demonstrated that the inner endocarp layer, which is similar in both hard and paper-shelled types, is the most important structural barrier to insect infestation. Shell-seal integrity and X-ray studies have confirmed that discontinuities at the inner endocarp suture seal are the primary, though not the sole site of entry for insect pests. Paper-shelled almond selections with highly lignified and well-sealed inner endocarps show resistance levels comparable to hard shelled types but with crack-out ratios 30% to 40% higher. Pseudo-paper-shelled types have also been selected, in which a highly lignified outer endocarp is formed, but is retained by the fruit hull at dehiscence. An understanding of endocarp morphology and development is thus important in breeding for insect resistance as well as the commercial utilization of both kernel and hull.

461

Genetic Diversity of *Castanea pulia* var. *ozarkensis*

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The genus *Castanea* includes several species, some of which, like the American chestnut (*C. dentata*) and chinkapin (*C. pumila*), are susceptible to chestnut blight,

caused by the Asian fungus *Cryphonectria parasitica*. Blight spread throughout the natural range of the American chestnut, destroying several billion trees within the past 50 years. Although the plight of the American chestnut is well-known, the chinkapin has been neglected. Taxonomic studies indicated two varieties, the Ozark chinkapin, var. *ozarkensis*, limited to the Ozark Highlands of Arkansas, Missouri, and Oklahoma, and the Allegheny chinkapin, var. *pumila*, found from New Jersey to Florida and Texas. The genetic diversity within and between 11 geographic populations of the Ozark chinkapin was evaluated to provide baseline genetic information pertinent to the conservation and restoration of this species. Nuts or dormant buds of chinkapin trees were evaluated for isozyme and RAPD polymorphism. The genetic variability of the Ozark chinkapin populations was relatively high when compared to the American chestnut, and most of the diversity resides within the populations. Conservation considerations for restoration of the Ozark chinkapin will be discussed.

462

Breeding and Improvement of Seguin Chestnut (*Castanea segunii*)

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The seguin chestnut, commonly called Maoli in China, is one of the three chestnut species (*C. mollissima*, *C. segunii*, and *C. henryi*) native to southeastern and central China. Seguine is a valuable germplasm resource for horticultural traits such as precocity, everbearing, high yield, blight resistance, and dwarfism. A recurrent selection breeding program was initiated in 1989. Since seedlings flowered as early as 3 weeks, selections were made annually for seven generations. Improvement in precocity, everbearing, yield, quality, blight resistance, and dwarfism is sought. The everbearing and high-yielding plants should provide an abundant source of food for wildlife on a continuing yearly basis. Incorporation of the precocious and dwarf traits into commercial chestnut species can enhance the development of high-density chestnut production.

463

AFLPs in Pecan Genetics Research

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Procedures were refined for extraction and amplification of DNA from pecan [*Carya illinoensis* (Wangenh.) K. Koch] leaf tissue. Genomic DNA was extracted from leaf tissue from multiple inventories of 'Wichita' and 'Pawnee' and processed for Amplified Fragment Length Polymorphism (AFLPs). Using only four AFLP primers, 26 polymorphisms were identified, verifying the reproducibility and consistency of amplification. The application and limitation of the procedure for separating genotypes will be discussed. Twenty-four cultivars and seedlings representing the geographic range of the species were analyzed using 10 primer combinations. Despite the small sample size, polymorphic bands apparently associated with geographic origin were apparent. Individuals from selected controlled-cross families of the Pecan Breeding Program were bulked according to disease reaction and screened using 64 primers. Primary primers were selected on the basis of polymorphisms observed in bulked samples of resistant and susceptible genotypes. Eighteen primer combinations were selected for use on all individuals in the test. The candidate markers were evaluated to verify that parental lines were polymorphic for the trait, reducing to one the number of appropriate primers. That primer was used to screen 84 progeny samples phenotypically rated for disease resistance levels. The data were analyzed for linkage to scab resistance in the population. Factors limiting the utility of AFLPs as tools for selection of disease resistant genotypes, and their use in developing markers for heterodichogamy (a simple dominant genetic system) will also be discussed.

464

A Phenotypic and Molecular Evaluation of Field-grown Trees Derived from Somatic Embryogenic Cultures

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Somatic embryogenic protocols have been developed for pecan, *Carya illinoensis* (Wangenh.) C. Koch, in which high multiplication rates and efficient

plant regeneration can be obtained. Regenerated plants were transferred into the field in 1995. Phenotypic and genetic comparisons were made of trees from two tissue culture lines to assess if plants derived from somatic embryogenic cultures maintain clonal fidelity and exhibit true-to-type characteristics. Genetic changes were examined using AFLP (Amplified Fragment Length Polymorphism) analyses. Shoot growth, leaf morphology, and the occurrence of scab (*Cladosporium caryigenum*) lesions and *Phylloxera* galls were evaluated. AFLP could readily detect differences between the tissue culture lines, which exhibited a higher number of polymorphic loci relative to comparisons within culture lines. Phenotypic characteristics differed between lines, but were generally consistent in trees within a culture line.

101 ORAL SESSION 21 (Abstr. 465–471)

Vegetable Crops—Breeding & Genetics

465

New Hybrid Tomato For Summer Season In Bangladesh

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Tomato is a winter vegetable in Bangladesh. The production of tomato in summer is limited because of high temperature, heavy rainfall and severe infestation of diseases. Recently Bangladesh Agricultural Research Inst. developed two varieties of tomato that can set fruits in summer with the application of Tomatotone (Parachloro phenoxy acetic acid) but, the yield is poor (24 t/ha). Hence, a program was initiated to develop hybrid tomatoes that can set fruits at high temperature without Tomatotone. In 1995 winter season half diallel crosses were made between seven selected inbred lines. Hybrid seeds of all crosses were collected and tested in 1996 summer season along with the parents. All the hybrids gave higher yield over the parents. The hybrid line TM0832 was the highest yielder and produced 424.7% higher yield over the better parent. Selected hybrids were further put into regional yield trial in Summer 1997 with the control variety BARI Tomato-4. TM0832 performed better in all the locations and produced 146.45% higher yield over the control. The distinguishing morphological characters of the hybrids are dwarf plants with less foliage coverage and profuse bearing (70–75 fruits/plant). Fruits of TM0832 matured in 60–65 days after transplanting and harvesting continued for a month. Fruits are globose, medium in size, solid and developed uniform red colour at maturity. Fruits have shelf life of 20 days at an ambient summer environment. The plants showed high degree of tolerance to bacterial wilt.

466

Evaluation of Tomato Varieties for Resistance to *Alternaria* Fruit Rot

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Alternaria alternata (Fr.:Fr.) Keissl. (syn. *A. tenuis* Ness.) causes severe rot of tomato fruits and reduction in yield under field conditions in south Texas. Several fungicidal control measures have been tried against the disease and incorporation of genetic resistance has been found to be economically feasible. The objective of this study was to evaluate resistance and susceptibility of fruits of different tomato cultivars to *Alternaria* rot. Twenty-five tomato varieties were grown in the field in a randomized complete-block design. Subsequently, the plants were inoculated two times at mature-green stage with *A. alternata* conidia suspension (10⁴ per ml) to promote moderate to severe fruit rot epidemics. Uninoculated fruits served as controls. Fruit rot incidence was measured by recording numbers of rotted fruit/plant per block and disease severity were rated on a scale of 0 to 3 at red-ripe stage. Three tomato varieties 'Celebrity', 'Golden Boy', and 'Colonial' had little or no fruit rot symptoms, with disease severity indices of less than 1.0. These varieties were regarded as resistant. The tomato varieties 'Duke', 'GH 761', 'Quick-Pick', and 'Heat-wave' had disease severity ratings greater 1.5 and were regarded as relatively resistant. The remaining tomato varieties with disease severity ratings greater than 1.5 were regarded as susceptible.

467

The *ffs* Allele Conditions Flower Stem Fasciation in Red Beet

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A fasciated flower stem character arose spontaneously during development of the red beet (*Beta vulgaris* L.) inbred line W411. The fasciated character is manifest by a flattened flower stem with petioles coalesced into a twisted, ribbon-like appearance. No fasciation is present in the vegetative stem or petioles. An inheritance study was conducted to determine the genetic control of flower stem fasciation. The inbred line W411 was used both as a male and female parent in crosses with four red beet inbred lines. Segregating progenies in both the BC₁ and F₂ generations were developed and scored for the fasciated flower stem character. Variable expression of the fasciated flower stem phenotype was observed in these progenies; however, the presence of flattened flower stems at the stem/hypocotyl junction was unequivocal. Chi-square goodness-of-fit tests in both the BC₁ and F₂ generations did not deviate significantly from expected ratios for a monogenic recessive character for each genetic background. No reciprocal differences were detected for any cross in this group of four inbred lines, which suggests the lack of maternal effect for the fasciated character. The symbol *ffs* is proposed to describe the genetic control of the fasciated flower stem phenotype.

468

Genetics and Breeding of Miniature Iceberg Lettuce

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Miniature vegetables have become mildly popular in the United States and elsewhere. These include small forms of carrot, pumpkin, bok choy, tomato, potato, corn, eggplant, squash, and watermelon. Some of the miniature vegetables are based upon harvest of immature edible portions. Others are genetically reduced in size. Miniature lettuce forms include romaine and butterhead cultivars, as well as young leaves harvested for mesclun, or baby leaf mixes. Miniature iceberg lettuce was derived from crosses of early flowering dwarf forms with standard iceberg lettuce cultivars. Three slow-bolting miniature cultivars, Ice Cube, Mini-Green, and Blush, were released from this program. Another miniature iceberg cultivar, LeCup, was developed by Asgrow Seed. Co. Crosses among these types and normal size iceberg cultivars showed that the two miniature types were based on two different single recessive genes with an epistatic relationship. Further breeding goals in the program will include earlier maturing miniature cultivars with variations in color, including green, red, and yellow.

469

Inheritance of Pod Calcium Concentration in Snap Beans (*Phaseolus vulgaris* L.)

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Significant variation for pod Ca concentration among snap bean genotypes was previously observed. To evaluate and better understand the genetics that control calcium concentration of pods in snap bean, two populations of snap beans were evaluated during the summers of 1995 and 1996 at Hancock, Wis. These populations were Ca2 ('Top Crop' x 'Evergreen') and Ca3 ('Slimgreen' x 'Evergreen'), therefore forming a half-sib structure. The experimental design used in this experiment was an 8 x 8 double lattice repeated each year. No calcium was added to the plants, which were grown in a sandy loam soil with 1% organic matter and 600 ppm Ca. To ensure proper comparison for pod calcium concentration among cultivars, only commercial sieve size number 4 pods (a premium grade, 8.3 to 9.5 mm in diameter) were sampled and used for calcium extractions. After calcium was extracted, readings for calcium concentration of extracts were made using an atomic absorption spectrophotometer. Statistical analyses resulted in distinct differences among genotypes and between years for pod calcium concentration ($P = 0.01$) in both populations. No significant year x genotype interactions were observed. To assess the power of selection for pod calcium concentration in snap beans, variance components and heritabilities are estimated and discussed.

470

Identification of Flavonoids from the Seedcoats of *Phaseolus vulgaris* L. Beans of Known Genotype for Seedcoat Color

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A number of pure flavonoid compounds have been isolated and identified from seedcoats of bean (*Phaseolus vulgaris*) with known genotypes for seedcoat color. Kaempferol-3-O- β -D-glucopyranoside was found to be the major seedcoat flavonol of the "brown" genotypes yellow brown (P C J G b v), mineral brown (P C J G B v), mat mineral brown (P C j G B v), buffy citrine (P C J g B v). This kaempferol glycoside was also found in a yellow bean ('prim' P C J g b v) of the manteca market class, but the diglycoside kaempferol-3-O- β -D-glucopyranoside-(2 1)- β -D-xylopyranoside was another major flavonol found in manteca. The "brown" genotypes also contained proanthocyanidins that are currently being characterized, but no tannins or proanthocyanidins were found in the manteca bean. Three main anthocyanins have been found in the three "black" genotypes, mat black, 5-593 and dark brown violet. Preliminary identification of the anthocyanins indicates the presence of delphinidin, petunidin and malvidin. Further work on identification of the minor anthocyanins is underway.

471

The *rp* Allele Alters Carotenoid Accumulation and Composition in Carrot Roots

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Previous studies have shown the lack of pigmentation in carrot root is dominant to the production of pigment. However, the *rp* allele causes a 92% reduction in total carotenoid pigmentation in roots of W266rprp. When homozygous recessive, the *rp* allele also appears to alter the carotenoid quality of carrot roots. The primary focus of this study was to investigate the effect of *rp* on the composition of carotenoids in two near-isolines of carrot, W266RPRP and W266rprp. Field experiments during 1996 and 1997 revealed that accumulation of total carotenoid concentration in W266RPRP and in W266rprp was 12.7 and 1.3 $\mu\text{g/g}$ dry weight, respectively. HPLC analyses showed W266rprp contained no α -carotene, whereas W266RPRP contained both α - and β -carotene. HPLC analyses of W266rprp also showed no accumulation of phytoene nor lycopene and due to the absence of α -carotene in W266rprp, thus it was hypothesized that the *rp* gene may cause a lesion in the β and/or ϵ cyclases. HPLC analyses also provided evidence that the *rp* gene is associated with a greater synthesis of a product that has a high absorbance at 296 nm and an elution time \approx 28.6 min in W266rprp. MALDI mass spectroscopy of HPLC-generated fractions eluting at 28.6 min revealed differences between W266rprp and W266RPRP, suggesting differential carotenoid composition between the two near-isolines.

102 ORAL SESSION 22 (Abstr. 472–479) Small Fruits—Crop Production

472

Source–Sink Relations in Non-dormant and Dormant Blueberry Production Systems

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Two cultivars of southern highbush blueberry (*Vaccinium corymbosum* interspecific hybrid) were grown in containers under the traditional dormant production system or the non-dormant production system. Plants in the non-dormant production system were maintained by continuous N fertilization throughout the year. The first objective was to determine when source limitations to reproductive development in blueberry occurred. The second objective was to determine if source limitations could be alleviated by the non-dormant production system, since photosynthesis and therefore carbohydrate accumulation continue later into the season. In order to determine when source limitations occurred, reproductive manipulations were applied to three groups of plants, either after flower bud differentiation in the fall, or after fruit set in the spring. After flower bud differentiation, 80% of the flower buds were removed from one plant group. After fruit set, 80% of individual fruits or 80% of fruit clusters were removed from two other plant groups. Average fruit dry weight was higher in the flower bud removal treatment than in the fruit removal or control treatments in the dormant production system, indicating a source limitation occurs prior to anthesis. No pre-anthesis source limitation was found in the non-dormant system; this is probably due to insufficient

fruit and flower removal, and/or continued flower bud initiation prior to anthesis in this system. However, both fruit number and total yield were significantly higher in the non-dormant than the dormant production system.

473

Establishment of a Non-dormant Blueberry (*Vaccinium Corymbosum* Hybrid) Production System in a Warm Winter Climate

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A high-density planting of three southern highbush cultivars was established in 1994 in southwest Florida to test the feasibility of a non-dormant blueberry production system. A non-dormant system involves continuous application of nitrogen throughout fall and winter, which enables the plants to avoid the normal dormancy cycle and the concomitant chilling requirement. Three nitrogen fertilizer rates and two organic soil amendments (municipal solid waste compost and acidic peat) were evaluated for effects on maintaining plant growth in this system. In general, increasing N rates from 84 to 252 kg·ha⁻¹ increased plant canopy volume, leaf retention, and rate of new vegetative budbreak. Plant height and volume were consistently greater for plants grown in the compost compared to the peat amendment, but there were no differences in leaf retention or vegetative budbreak between the two soil amendments. Flower bud density and fruit yield were increased in plants grown in the compost compared to the peat, while N rate had no effect on either. Plants in this non-dormant system have shown no deleterious growth effects, suggesting that establishing a blueberry planting in a warm winter climate is feasible under the described conditions.

474

Budbreak of Rabbiteye Blueberry Enhanced by Hydrogen Cyanamide

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Few flower buds on pot grown 'T-227' rabbiteye blueberry (*Vaccinium ashei* Reade) advanced past stage 1 (tight bud) when exposed to 0 or 200 h of chilling temperatures (4 °C), regardless of treatment with hydrogen cyanamide. However, 0.25%, 0.5%, 1%, and 2% sprays on plants chilled 400 h advanced flower bud development through stage 6 (open). Sprays were less effective on plants chilled for 600 h or longer, and 1% and 2% sprays caused some phytotoxicity regardless of chilling.

475

Hydrogen Cyanamide Increases Leafing and Reduces Fruit Development Period of Southern Highbush Blueberry

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Mature, field-grown 'Misty' southern highbush blueberry plants were sprayed to drip with 0, 20.4, and 10.2 g·L⁻¹ concentrations of hydrogen cyanamide in north-central Florida on 20 Dec. and 7 Jan. 1996–97. Plants were dormant and leafless, with slightly swollen flower buds, at the time of spray applications. All hydrogen cyanamide sprays increased the extent and earliness of vegetative budbreak and canopy establishment. The number of vegetative budbreaks per centimeter of shoot length increased linearly with increasing spray concentration of hydrogen cyanamide. Hydrogen cyanamide-treated fruit had greater average fresh weights and shorter average fruit development periods than non-treated fruit. On 15 Apr., 40% to 60% of hydrogen cyanamide-treated fruit were ripe compared to about 10% of control fruit. Some flower bud damage and subsequent fruit thinning was observed from the 20.4 g·L⁻¹ spray, especially at the later spray date. Hydrogen cyanamide shows potential for increasing early fruit maturity and fruit size of some southern highbush blueberry cultivars in Florida.

476

Lowbush Blueberry Response to Different Phosphorus/Nitrogen Ratios

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Lowbush blueberries (*Vaccinium angustifolium* Ait.) in three commercial fields were treated with 67.2 kg P/ha from triple super phosphate (TSP), monoammonium phosphate (MAP), or diammonium phosphate (DAP) and compared to

a control in a randomized complete-block design with 12 blocks. Correction of P deficiency by fertilizers with different ratios of P to N was assessed by leaf nutrient concentrations. Samples of stems collected in July from three 0.03-m² quadrats per treatment plot indicated MAP and DAP had no effect on dry weight of stem tissue, but increased average dry weight of leaf tissue. P and N Leaf concentrations were raised to higher levels by MAP and DAP than by TSP. TSP had no effect on leaf N concentrations but raised leaf P concentrations compared to controls. Stem length, flower buds per stem and flower bud density were increased by both MAP and DAP, but not TSP. MAP and DAP increased fruit yield by about 340 kg/ha compared to the control.

477

Affect of Pre-plant Amendment, Mulch, and Nitrogen Level on Mature Highbush Blueberry Root Growth and Mycorrhizal Infection Intensity

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The affect of pre-plant rotted sawdust amendment (with and without), mulch (with and without), and nitrogen level (four levels, ranging from 0 to 160 g/plant) were evaluated for their affects on highbush blueberry root and mycorrhizal infection intensity in a field study that was instigated in 1992 at the Russell E. Larson Agricultural Research Center in Rock Springs, Pa. Over the years, mycorrhizal infection intensity was affected interactively by these treatments, however in general, it was negatively correlated with nitrogen level, mulch, and pre-plant amendment. Plants were excavated in Oct. 1998, and it was found that fine feeder roots constituted a much higher percentage of total root mass in unmulched plants, as well in high nitrogen plants, however there was an interaction between nitrogen level and mulching, such that non-mulched high N plants had a higher proportion of feeder roots. Total root mass was unaffected by mulch and pre-plant amendment; however it was increased by nitrogen. Root systems were also sampled for mycorrhizal infection intensity from different locations on the root system and are currently being analyzed.

478

Calcium Sulfate Soil Amendment Reduces Incidence of Phytophthora Root Rot in Raspberry

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Phytophthora is a debilitating root disease of many crops, and limits raspberry production in much of the world. Two fungicides are labeled for use against Phytophthora on raspberries in North America, but they are not effective when disease pressure is severe. We were interested in the effect of preplant soil amendments such as composts, fertilizers, gypsum and limestone on the incidence of Phytophthora in red raspberries. Various amendments were incorporated simultaneously at two sites prior to planting raspberries. Both sites had identical soil, but one had a known history of *P. fragariae* var. rubi and the other had no history of raspberry production. Differences in survival and plant growth of 'Heritage' among fertilizer (ammonium nitrate, phosphorus acid), compost, gypsum and lime (calcitic or dolomitic) treatments were small in the uninfested site, whereas differences were large in the infested site. Gypsum (CaSO₄) treated plots had higher yields and greater cane diameter, density, and height compared to control plots after 2 years. Plants in compost amended plots exhibited the most severe disease symptoms; liming had little effect. In a second field experiment, various sources of calcium and sulfate were compared in an infested site. As before, plants in calcium sulfate-amended plots performed better than plants in control plots or in plots amended with sulfur or potassium sulfate. In a greenhouse experiment using infested soil and artificial flooding, calcium sulfate also reduced disease incidence in 'Titan' compared to unamended soil. Data from these three experiments suggest that gypsum could be used in an integrated approach to Phytophthora management in raspberries, and perhaps other crops as well.

479

Physiological Evaluation and Field Assessment of Floricane Productivity of Cold-damaged Red Raspberry in a "Recovery" Year

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The two test sites paired perennially cold-damaged portions of field vs. controls were monitored and assessed the same as last season. The winter of 1996–97 did not produce the same level of winter injury as the previous winter, thus this season was an opportunity to evaluate the effects of a “recovery” year. The overall cane lengths and bud number per cane were higher in the previously winter injured plots of both fields compared to the control. It showed the previous injured plants with a reduced crop load in 1996 were able to devote more energy into developing the 1997 crop. However, damaged plots still had higher cane dieback, percentage of cane dieback, number of dead or dormant buds per cane, and percentage of dead or dormant buds in both sites, especially at site 2, even in a mild 1996–97 winter. The control plots had greater average lateral length, total lateral length, and higher berry numbers per lateral, especially in laterals from primary buds at both sites. Thus, a mild winter reduced productivity of the floricanes and its laterals in the cold damaged plots. The differences in fruit yield and its components between the check and the cold-damaged ones were not significant this season. Leaves on the cold damaged floricanes had greater photosynthetic activity after harvesting than the control. The winter-injured plants with a reduced leaf area may show higher demand for photosynthate.

103 ORAL SESSION 23 (Abstr. 480–487) Extension Horticulture

480

Researching Alternative Cash Crops for Small Scale Farmers in Southern Ohio

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Specialty crops are great alternative cash crops for small scale farmers. Small scale farmers are constantly searching for viable economic crops to grow. We have been conducting applied research on the production and marketing of culinary herbs, oriental vegetables, colored peppers, and muskmelons to name a few. These crops show excellent potential for southern Ohio. Field demonstration, seminars, and surveys were used to gather and disseminate information on these specialty crops. More than 230 people attended our seminars on alternative cash crops. More than 150 people attended our field days. In addition, we had identified many chefs that are willing to purchase from local specialty crop growers. It will be a win-win situation for both chefs and growers. Growers will be able to maximize their profitability while chefs will receive fresh and unique produce. As a result of our research, we were able to show small scale growers what they can grow successfully and how they can market their crops for most profit. These applied research projects received a combined funding of \$10000.00 from OSU Extension-Innovative Grant program. These projects are a great way to establish credibility among clients. We would also like to demonstrate how other extension agents can help their clients. A lecture utilizing slides and overhead transparencies will be the format of the seminar.

481

Colorado Commercial Greenhouse Needs Assessment Survey—1997

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Greenhouse crop producers in Colorado were surveyed in the fall of 1997 to determine their educational, extension, and research needs and expectations. Four mailings were made to a mailing list of 180: pre-letter, cover letter and survey, follow-up post card, and post-letter with another survey sent only to those who had not responded after the third mailing. One hundred and six usable surveys were returned for a rate of 59%. The survey itself consisted of five sections: Educational Programming Topics, Educational Programming Delivery Methods, Research Needs, Extension Needs, and Personal/Business Data. Results were tabulated via simple frequencies. In the area of Educational Programming Topics, 66% of respondents wanted to learn more about non-chemical pest control and 63% were interested in production of perennials. In Educational Programming Delivery Methods, 76% preferred workshops with the most favorable months for attendance being January, September, and October. In the area of Research Needs,

64% wanted explorations into new crops in general and 73% were interested in new insect management strategies. In the Extension Needs section, 76% expected a field visit from extension personnel on an as-needed basis and 51% were familiar with services offered by extension greenhouse specialists. Finally, in the Personal/Business Data section, 43% reported that they held a bachelor's degree, 50% had 16 or more years experience in the industry, and 50% worked in greenhouses less than 50,000 square feet in size.

482

Extending Biologically Integrated Farming Practices within the San Joaquin Valley's West Side

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The West Side On-Farm Demonstration Project is a large-scale extension program consisting of farmers, researchers, extension advisors from the Univ. of California, and other private and public agency consultants who are evaluating biologically integrated soil-building and pest management practices within a participatory and on-farm demonstration context. Modeled after the Biologically Integrated Orchard Systems (BIOS) Projects that were originally sponsored by the Community Alliance with Family Farmers, the goals of this project are to facilitate information exchange among West Side farmers, consultants and researchers on soil-building practices and options for reduced reliance on agrichemical inputs, to monitor and evaluate on-farm demonstrations of soil-building practices, including cover cropping and organic soil amendments, and to determine the extent to which IPM practices are utilized in row crops on the West Side and identify constraints preventing further adoption of biologically intensive pest management practices. The Project has generated several adjunct research activities and considerable regional attention. A summary of ongoing impact assessment efforts will be presented.

483

Consumer Perceptions of Plant Quality

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Plant quality has been identified as one of the most important factors in determining where retail customers shop and which plants they buy. A better understanding of what customers actually mean by “plant quality” can enhance the industry's ability to give customers what they want, and improve the competitive position of individual nursery/garden center businesses. Five common woody ornamentals—flowering dogwood (*Cornus florida*), red maple (*Acer rubrum*), azalea (*Rhododendron* spp.), nandina (*Nandina domestica*) and ‘Compacta’ holly (*Ilex crenata* ‘Compacta’)—were selected for a three-part study of consumer perceptions of plant quality. The first component of the study was comprised of three focus groups, conducted during Summer 1995 in New Bern, N.C., and Fall 1996 in Raleigh, N.C. The purpose of the focus groups was to learn more about the specific quality attributes customers use in evaluating trees and shrubs in the garden center. The second component consisted of five different intercept surveys conducted in 1997 and 1998 in Virginia, North Carolina, South Carolina, Florida, Georgia, Alabama, and Tennessee. Purchase intent, rank order, paired comparison, dollar metric and constant sum scales, accompanied by photographs of plant material, were used to interview retail customers in independently-owned garden centers. These studies focused primarily on azaleas and dogwoods. The third component was a hedonic study focusing on azaleas and ‘Compacta’ holly, conducted in the Raleigh, N.C., area in Apr. 1998. Using standard regression analysis techniques, hedonics examines prices and levels of selected attributes to provide an estimate of the marginal implicit price a consumer is willing to pay for an additional unit of a particular attribute.

484

U.S.–Hungarian Horticultural Research Program for Stress-tolerant Ornamental Plants

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Pollution has become one of the most important problems in urban and industrial environments and plants are considered to be one of the best means

for diminishing its harmful effects. Installation of landscape plants is probably the cheapest and one of the most effective ways to reduce the adverse effects of polluted or stressful environments. Resistance or tolerance of various plant species against environmental stresses (e.g., pollution, drought, high salt content and poor aeration of soil, human damage) varies dramatically with type of plant species and cultivar. Nebraska and Hungary have many similarities in climate and geographical characteristics and researchers have accumulated considerable results in the field of plant environmental stress and pollution tolerance. However, time and history have prevented cooperative work until recently. Excellent connection and cooperation with the Univ. of Horticulture and Food, Budapest and several Hungarian nurseries was established by the Dept. of Horticulture, Univ. of Nebraska—Lincoln and the Nebraska Statewide Arboretum, which was an optimal foundation for this research project. Our overall goal was to mutually utilize the rich genetic materials and experience which have accumulated in these two regions during the past 5 decades. This continues to be accomplished by a systematic germplasm-exchange program and testing pollution- and stress-tolerant tree, shrub and herbaceous perennial cultivars, along with investigations of the physiological mechanisms of their stress reactions and biotechnological methods for mass-propagation. The presentation will highlight the main results of this several years long joint program.

485 Contract Growing for the Export-oriented Cut Flowers Industry in Turkey

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Thirty cut flower businesses were surveyed in 1997 to examine the production structure and main problems of export-oriented contract growing in Turkey. The survey was conducted in Antalya province, which is the center of export-oriented cut flower production in Turkey. The results of the research provided insight into how Turkish cut flower-contracted growers were managing some of the key areas of their operations. The study also provided the opportunity for growers to highlight their concerns about contract growing for export-oriented cut flower production. The survey showed that contract growers do not use specific performance indicators relevant to cut flower production. The product price received by the contract growers was determined by the export companies. These export companies receive flowers from growers mainly on consignment. After exporting the products, exporters periodically pay the grower, subtracting a commission for their services and other marketing expenses. Contract growers are essentially price takers in the transactions. The business procedure from production to price setting and marketing was not in the hands of the contract growers. Therefore, the trading risks are essentially borne by the contract growers. The main concerns raised by contract growers were the current consignment system, cost of the plant materials, and the late payment for the sold products.

486 Development of REDCAHOR—a Vegetable Research and Development Network in Central America

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REDCAHOR is the Spanish acronym for "Central American Vegetable Network." Vegetables have traditionally been an important source of nutrients and vitamins in the diet in Central America. Vegetable production in this region is now changing as local consumers are demanding increased diversity and quality and international markets are expanding with "non-traditional" vegetable exports. The present restraints to expanded research and production of vegetables in the region include i) need for cultivars with increased insect and disease resistance, ii) poor and excessive use of pesticides, and iii) inadequate postharvest technology. In addition, there are few vegetable researchers in the region and response to their activities have not been coordinated. The goal of REDCAHOR is to develop a regional network of national institutions that can prioritize agendas and cooperate to maximize the impact of available resources. Establishment of a system of regional trials and cooperative regional programs in integrated pest management and plant breeding are currently under development. A series of regional workshops are planned, including integrated pest management, maintenance and use of genetic resources, organic production, and greenhouse production. In addition, REDCAHOR, in collaboration with the Escuela Agrícola Panamericana

in Honduras, will offer regional short-course training in vegetable breeding and genetics as well as vegetable production and management, including integrated pest management.

487 Implementing a Tomato Disease Forecast System in Northern New Jersey

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After 4 years of research trials with TOM-CAST, an early blight and anthracnose forecaster for tomatoes, forecast information was made available to northern New Jersey growers in 1997. Rutgers Cooperative Extension provided 20 tomato growers with information and training on using TOM-CAST to schedule fungicide applications. Rutgers Cooperative Extension set up and maintained six weather stations in a three-county area. Rutgers personnel downloaded weather data twice weekly from May to late October and generated and published disease severity values (DSV) by phone and fax. Growers obtained DSVs for their site from the nearest weather station(s) and used them to determine their spray schedule. A survey to determine grower use of and attitudes about the system were mailed in Oct. 1997. Four growers used the system to schedule fungicide applications. Growers reported the following perceived advantages of using TOM-CAST: cost savings and savings to environment; disease forecasting being "the future" of disease management; knowing for sure when to spray. Growers reported the following perceived disadvantages: risk to crop; inconvenience of an irregular spray schedule; concern about other diseases. Growers who did not use the system in 1997 were queried about the reasons they did not use it and whether they would consider using TOM-CAST in 1998.

116 ORAL SESSION 24 (Abstr. 488–492) Fruits—Breeding & Genetics

488 Evaluating Transgenic Apple for Resistance or Tolerance to Apple Replant Disease

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Apple replant disease (ARD) causes serious problems in most fruit-growing regions worldwide. It is associated with nematodes, fungi, bacteria, and other deleterious factors. Its symptoms range from severe stunting to death of replants in old orchards. We evaluated effects of antibacterial (cecropin-, attacin- and hen egg white lysozyme-encoding) and antifungal (chitinase-encoding) transgenics, obtained from the apple-rootstock breeding program at Geneva, N.Y., on ARD. Transgenics were tested in a composite soil collected from New York orchards with known replant problems. The ARD-infested field soil (FS) had ≈ 675 *Pratylenchus penetrans* (root-lesion nematodes, RLN) and ≈ 75 *Xiphinema americanum* (dagger nematodes) per liter pot; soil for controls was steam-pasteurized. Height, biomass, nematode vermiforms and eggs were recorded after ≈ 60 days under optimal growing conditions in the greenhouse. There was significant variation in growth and *Pratylenchus* counts among transgenics ($P < 0.00$), most of which were susceptible to ARD. However, endoparasitic RLN accounted for $< 50\%$ of the variation in biomass, suggesting that other factors were important in affecting plants. Conversely, RLN significantly increased root necrosis ($P < 0.00$; $R^2 = 80\%$). Eggs were observed in diseased chitinase-encoding lines, probably because of low-gene expression. There was no significant difference in eggs among the lines ($P \leq 0.3$). Apparently, good growth was inconsistent and due to confounding factors such as mild ARD. These results suggest that single-gene therapy and low-gene expression may not protect apple against ARD complex, instead gene-pyramiding and high-gene expression should be tested.

489 Advanced Selections of Summer Apples from the Arkansas Apple Breeding Program

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An apple breeding program was begun in Arkansas in 1966 with objectives including the development of early maturing cultivars adaptable to warm environments. Several advanced selections have achieved this objective and are briefly described here prior to possible introduction as new cultivars. AA-50 (PCR3-120 x PCR4-56) mature 65–75 days after bloom, are moderate size (120–160 g), round, tart, juicy; red over green/white ground color. Fruit are similar to 'Jonathan'. AA-63 (Jersey Mac x AA-11) mature 70–85 days after bloom, are moderate size (130–180 g), round, somewhat tart but with good sugars for maturation season, are dark red/purple striped with pronounced lenticels on a green/white ground color. AA-18, aka 'Arkcharm' (NJ123249 x NJ136055) ripen 85–100 days after bloom, are medium to large size (165–195 g), slightly conic, bright red on green ground/yellow color, are very crisp and firm, tart with good flavor, good shelf-life for season (7–21 days) and extended harvest period (two to three harvests). AA-44 (NJ674016 x NJ40), mature 90–105 days after bloom, are large (180–210 g), round, red with some dark red striping with green ground color; fruit have moderate acid content and are relatively sweet, require two to three harvests and have a storage life of 2–4 weeks. AA-64 (SpurGold x AA-26) mature 110–120 days after bloom, are yellow, conic, russet free, often have a pink blush, are moderate to large size (160–200 g), firm, subacid, and sweet.

490

Transfer of Plum Pox Virus Coat Protein Genes from a Plum Pox-resistant Transgenic Clone of *Prunus domestica* Plum to Its Progeny through Hybridization

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Sharka or plum pox virus (PPV) is a major disease of stone fruit and causes severe economic losses in Europe. There is little resistance to PPV in most *Prunus* species, thus genetic engineering represents a potentially useful approach to obtain resistant germplasm. Transgenic plums containing the PPV coat protein (CP) or the related papaya ringspot virus (PRV)-CP gene were produced through *Agrobacterium tumefaciens*-mediated transformation. These transgenic plum clones were then evaluated for resistance to PPV infection in the greenhouse by graft or aphid inoculation with PPV. While symptoms of PPV appeared in most transgenic clones, all plants of PPV-CP transgenic clone C5 were symptomless and ELISA and immunocapture-reverse transcriptase PCR negative for over three years following inoculation with two strains of PPV (Ravelonandro et al., Plant Dis. 81:1231-1235, 1997). Clone C5, which contains multiple copies of the PPV-CP gene, was hybridized with PRV-CP transgenic plants or untransformed plum cultivars. Progeny were obtained containing no transgenes, only the PPV-CP, only the PRV-CP, or both the PRV-CP and PPV-CP transgenes. Seedlings were inoculated with PPV. At 5 and 11 months post-inoculation, seedlings containing the PPV-CP genes from C5 were symptomless and ELISA negative. Seedlings containing only PRV-CP transgenes or non-transformed controls showed symptoms of PPV infection and were ELISA positive. These results indicate that the PPV-CP transgenes can be transferred to progeny through hybridization and that these genes can impart resistance to PPV in transgenic seedlings. The inheritance of the multicopy inserts of the PPV-CP and PRV-CP transgenes is being analyzed. The combined effects of both transgenes on resistance to PPV and the stability of PPV resistance in the progeny of the resistant C5 transgenic line are currently under evaluation.

491

An S-locus Receptor Protein Kinase from Peach is Expressed Predominantly in Fruit and Responds Differently to Various External Stresses

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A receptor-like protein kinase (RLK) isolated from December peach bark (Ppsr1k1) was previously shown to have considerable homology to the S-locus class of RLKs associated with reproductive self-incompatibility. Unlike those RLKs, transcripts arising from Ppsr1k1 were not detectable in standard RNA

blots. To determine the pattern of expression of this gene, RNAs from various peach tissues, some of which had been subjected to different stress treatments, were surveyed using Reverse Transcript-PCR (RT-PCR). Based on these results, select RNAs were further quantitated by Competitive PCR (C-PCR). RT-PCR of RNAs from seasonal peach bark revealed little change in the relative abundance of Ppsr1k1, although a slight decrease was noted in the RNAs from October and December bark. Expression of Ppsr1k1 in developing peach fruit peaked at stage II and declined thereafter from stage III and in the later stages of ripening. Ripe peach fruit subjected to 10 min UV treatment or wounding followed by application of a yeast biocontrol agent showed a further decline in Ppsr1k1 expression; C-PCR analysis of the wounded fruit indicated a five-fold difference in expression between wounded water controls and wounded fruit treated with the biocontrol agent 48 h after treatment. In bark and xylem tissues under water deficit conditions expression of Ppsr1k1 declined. In contrast, levels of Ppsr1k1 in leaves and roots increased. C-PCR of the root samples revealed a 50-fold increase in the transcript in response to water deficit.

492

Mapping Cold Tolerance QTL in *Citrus grandis* (L.) Osb. x *Poncirus trifoliata* (L.) Raf. Hybrids: A Three-pronged Approach

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A pseudo-testcross population of *Citrus grandis* selection DPI6-4 x *Poncirus trifoliata* cv. Rubideaux, cold-sensitive and cold-tolerant parents, respectively, is being used to map quantitative trait loci (QTL) for cold tolerance using bulked segregant analysis (BSA), selective genotyping, and interval mapping. A population of 500 young trees was frozen under controlled conditions to -9 and -15 °C to select contrasting bulk segregant populations from the distributional extremes of cold tolerance. A randomly selected subset of 61 individuals from this population was used to construct a linkage map for interval mapping. The pseudo-testcross population allows mapping of both the *C. grandis* and *P. trifoliata* genomes through the identification of parental origin of marker alleles. Screening of random 10-mer primers is ongoing and, to date, ~100 primers have produced eight markers showing differences in mean stem dieback between the bulked populations. MAPMAKER-QTL was used to analyze all markers (122 presently) on the linkage maps for correlation to QTL for cold tolerance or susceptibility, and two regions of interest have been identified. Also, markers linked to those identified through BSA are being analyzed for association with QTL through selective genotyping. The goal of this research is to identify genomic regions and associated markers relating to QTL for cold tolerance for future use in *Citrus* cultivar improvement.

117 ORAL SESSION 25 (Abstr. 493–498A) Fruits—Fruit Development/Postharvest

493

Characterization of α -Farnesene Synthase from 'Delicious' Apples

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α -Farnesene metabolism is associated with the occurrence of superficial scald in pome fruits. *Trans,trans*- α -farnesene synthase, which catalyzes the terminal step of α -farnesene biosynthesis viz. conversion of farnesyl pyrophosphate to α -farnesene, has been characterized in the extract from skin tissues of 'Delicious' apples (*Malus domestica* Borkh.). The total and specific activities of the enzyme were the highest in the cytosolic fraction when compared to that in membrane fractions. The enzyme possessed a pH optimum of 5.6 and required a divalent metal ion (Mg^{+2} and Mn^{+2} were preferred). The activity was highest between 10 and 20 °C, although 50 % of the activity was still retained at 0 °C. The presence of thiol reagents, pyridine dinucleotide effectors, anaerobic conditions or antioxidants did not significantly affect enzyme activity. α -Farnesene synthase activity was similar in the extract of skin tissue from scald-developing and non-scald-developing apples. The enzyme activity was not correlated to the inherent nature of scald-susceptibility or resistance in eight different apple cultivars tested.

Components of Apple Fruit Epicuticular Wax and Growth of Sooty Blotch Disease

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Sooty blotch severity varied among: 'Smoothie Golden Delicious', 'Coop-17', 'Liberty', 'NY65707-19', and 'NY61356-22', apple cultivars surveyed in this study, *Peltaster fructicola* Johnson, Sutton et Hodges, and *Leptodontidium elatius* (F. Manganot) Hoog were grown on compounds that make up the epicuticular wax of the fruit in order to determine if one or more wax compound acted as a substrate for growth, or if a growth modifier could be identified. There were no relationships between the major epicuticular wax components of each cultivar and the severity of the disease. *P. fructicola* and *L. elatius*, two of the most important sooty blotch fungi, did not grow on any of the five major components of the epicuticular wax. SEM studies showed that mycelia of *P. fructicola* grew on the surface of the wax and did not appear to degrade it. In view of the fact that conidia germination requires pre-treatment with dilute apple juice and the fact that SB does not grow on fruit cuticles where russet creates an impermeable layer. We conclude that the SB fungi are epiphytic and obtain their nutrients primarily from fruit leachates and not from components of the cuticle.

495

Developing a Quality Index for New Cherry Cultivars Growing in the San Joaquin Valley

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Sensory evaluation studies including trained panel and consumer in-store acceptance tests were carried out to develop a quality index for early cherry cultivars. A trained taste panel was used to study how cherry physical parameters are related to the perception of sweetness, sourness, and cherry flavor. Based on this information, we conducted an in-store consumer test. In the in-store consumer test, 'Brooks' cherries with a SSC $\geq 17\%$ were accepted by significantly more consumers than 'Brooks' cherries with an SSC of $\leq 16\%$. 'Brooks' cherries with a SSC of 17 to $< 20\%$ were "liked" by 74.2% of the consumers tested. When the SSC was $\geq 20\%$, 96% of the consumers tested "liked" them, while only 12.6% acceptance for cherries with a SSC $< 16\%$. There were no significant differences in acceptance of cherries with SSC $\geq 17\%$ between genders. However, when the SSC was $\leq 16\%$, significantly more female than male consumers "liked" them, 17.5% vs. 2.6%, respectively. A 4-year orchard survey on the relationship between skin color and SSC is also discussed.

496

Developing a Quantitative Method to Evaluate Peach and Nectarine Flesh Mealiness

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A quantitative method to measure peach and nectarine flesh mealiness was developed. To measure "free water", ≈ 30 to 40 g of fruit tissue was wrapped with four layers of cheesecloth (20 x 20 cm) and subjected to 17.4 N of force using a prototype press. After the fruit tissue was pressed for 1 min, the force was released. Pressing of the fruit tissue was repeated four times, after which no further juice or pectins were released. The juice was collected and centrifuged at 6,000 *xg* for 10 min. The residue was discarded and the supernatant was weighed and used to represent "free water" from the tissue. The percentage of "free water" had a higher correlation to mealiness perception by a trained taste panel and visual observation than the percentage of juice. This "free water" measurement is an objective and reliable method to evaluate genetic material, physiological changes during storage, and any treatment's effect on mealiness.

497

Thermal Blast Shelling of Nuts

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Thermal blast shelling has proven effective in removing the shells from filberts, chestnuts, almonds, pecans, and coconuts. Shells were completely removed from nuts and the nuts were blanched in a single operation. Thermal Blast shelling was accomplished with an apparatus that confined nuts in a pressure vessel, supplied intense heat for a short duration, then instantly opened the vessel to atmospheric pressure. The result was an explosion that blew the product from the vessel and simultaneously exploded the shell from the nut. Blanching was complete with all testa removed from kernel convolutions during the shelling of filberts, chestnuts, and almonds. Pecans required conditioning to an optimum moisture level and a heating medium comprised of superheated steam and air to avoid kernel damage.

498

Commodity Heating Medium and Mexican Fruit Fly Mortality

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The objective of this research was to investigate whether the medium used to transfer heat to a commodity influenced the mortality of Mexican fruit fly larvae. A similar 2-h heat dose was delivered to grapefruit via immersion in a variable temperature water bath or via exposure to a rapidly circulating gas. The concentration of oxygen and carbon dioxide inside the grapefruit was analyzed at 30-min intervals and grapefruit center temperatures recorded every 60 s during heating. The mortality of larvae located inside grapefruit during heating in a controlled atmosphere or in hot water was significantly higher than that of larvae located inside grapefruit heated in air. The internal atmosphere of grapefruit heated in a controlled atmosphere or in hot water contained significantly higher levels of carbon dioxide and lower levels of oxygen than grapefruit heated in air. Larval mortality was compared after larvae were heated in media by rapidly circulating air or by an atmosphere containing 4 kPa of oxygen and 18 kPa of carbon dioxide to evaluate whether the altered atmosphere or a heat-induced fruit metabolite was responsible for enhanced mortality. The significantly higher mortality of larvae heated in media in the presence of an altered atmosphere suggested that the altered atmosphere enhanced larval mortality. Results from this research suggest that reducing oxygen and/or increasing the level of carbon dioxide during heating can enhance mortality of the Mexican fruit fly and potentially reduce the heat dose required for quarantine security.

498A

Effects of UV-B Irradiance on Blueberry Storageability, Quality, and Shelf Life

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Blueberry fruits (*Vaccinium ashi* Reade cv. 'Tifblue'), divided into two groups, were subjected to UV-B irradiance (between 280 and 310 nm) to evaluate fruit storageability and shelf-life under cold conditions. Two Westinghouse FS40 sunlamps were mounted above the fruits of each group as the source of UV-B radiation. The emission from the FS40 lamps was filtered through 0.005 mm cellulose acetate (+UV-B) and through 0.005 mm mylar (-UV-B) and served as a control. UV-B lamps were turned on for 6 h daily and filters were changed every week to avoid solarization. Storageability, quality, and shelf-life of blueberry fruits stored under UV-B radiation were better than similar fruits stored under the same conditions without UV-B radiation. Fruit quality parameters varied between the two treatments.

118 ORAL SESSION 26 (Abstr. 499–505)

Vegetable Crops—Breeding & Genetics

499

Ploidy of Regenerated Broccoli Derived from Microspore Culture Versus Anther Culture

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Anther and microspore culture are commonly utilized to produce doubled-haploid (diploid), homozygous lines in broccoli (*Brassica oleracea* L. Italica Group). It is well-documented that doubled-haploid regenerants are produced by means of polyploidization during anther culture. However, polyploidization may not occur at all, or it may involve a tripling or quadrupling of the chromosome complement. As

a consequence, regenerated populations from anther culture contain diploids, but also haploids, triploids, and tetraploids. Microspore culture represents a simpler and more direct method for producing doubled-haploids. Although a similar mix of ploidy types is likely to be observed among regenerants derived from microspore culture, the actual ploidy levels of such regenerants have not been documented for broccoli. Thus, the objectives of this study were to compare ploidy levels of regenerants developed using both anther and microspore culture in broccoli, and to examine phenotypic variation in ploidy makeup of populations developed from both anther and microspore culture using different F₁ hybrids. Broccoli regenerants were derived simultaneously from both anther and microspore cultures using the same four F₁ hybrids, including Everest, Patriot, Greenbelt and Major. Ploidy level was determined by flow cytometry. A majority of regenerants derived from both anther and microspore culture, were determined to be diploids or tetraploids. Significant differences in ploidy makeup of populations were observed among hybrid varieties for both culture techniques. Regardless of the culture method used, 'Everest' produced a greater percentage of diploids and a lower percentage of tetraploids than 'Patriot' did. Haploids were observed more frequently from microspore culture than from anther culture when 'Everest' and 'Major' served as parents.

500

Environmental and Genetic Factors Affects Frequency of Tetraploid Regenerants from Immature Cotyledons of Melon

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Immature cotyledons of three inbred melon genotypes, *Cucumis melo* L., and all hybrid cross-combinations were placed for a 1-week treatment on liquid/membrane system prior to 5-week regeneration culture on a MS medium containing 10 µM benzyladenine. Moving plants from agar to liquid/membrane culture system altered the frequency of tetraploid regenerants. The frequency of tetraploidy was also effected by sucrose level during the 1-week liquid treatment. The most stressful conditions, those where the least regenerants were found, had the highest number frequency of tetraploidy. Genotypic variation in the modes of genetic control was observed in the different environments. Tetraploid variation can be manipulated by one week treatment of immature cotyledons prior to regeneration.

501

Resistance to Lettuce Infectious Yellowing Virus in Melon

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Yellowing of melon (*Cucumis melo* L.) incited by lettuce infectious yellowing virus (LIYV) reduces yield and fruit quality of infected plants. LIYV is transmitted only by the sweetpotato whitefly (*Bemisia tabaci* Genn.). Two naturally infected field tests indicated several potential sources of resistance to LIYV. PI 124112 and 'Snake Melon' had mild symptoms in both field tests whereas PI 313970 was asymptomatic in the test in which it was included. In greenhouse tests using controlled inoculation, PI 313970 was asymptomatic, had negative ELISA assays for LIYV, and was negative for LIYV in serial transfers to *Chenopodium*. 'Top Mark' and 'PMR 5' were symptomatic, had positive ELISA assays for LIYV, and were positive for LIYV in serial transfers to *Chenopodium* in these greenhouse tests. Limited data indicate that resistance in PI 313970 is conditioned by a single, dominant gene.

502

Disease Resistance and Yields of Transgenic and Traditional Summer Squash

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Kentucky vegetable growers exploiting a fall-harvested market window for summer squash (*Cucurbita pepo* L.) usually encounter severe virus and fungal disease pressure resulting in serious yield and quality reductions. Twenty-five summer squash varieties or advanced breeding lines (9 zucchini, 8 yellow straightneck, and 8 crookneck entries) were evaluated in a late summer planting for yield, quality, and disease resistance at the Univ. of Kentucky South Farm in Lexington. Both genetically engineered virus-resistant materials and new resistant/tolerant varieties from traditional breeding programs were compared with our recommended

hybrids. Border rows of a virus-susceptible variety were planted alongside and between each of the four blocks to enhance virus spread throughout the trial. Virus incidence was determined visually before and after final harvest and leaf samples were collected for virus assays. Virus symptoms were absent or difficult to see on zucchini squash plants during most of the trial but became obvious near the final harvest date. Varieties from traditional breeding programs having virus tolerance were among the highest yielding zucchini types. Traditionally-bred cultivars with the precocious yellow gene and two transgenic lines were in the highest yielding group of yellow straightneck squash—in spite of high virus incidences in precocious yellow cultivars. Transgenic cultivars were clearly superior in terms of yields among yellow crooknecks with yields nearly double those of the lowest yielding traditional hybrids. Cultivars and breeding lines varied considerably in color, shape, overall appearance, and potential marketability.

503

Field Screening for Onion White Rot Resistance

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Onion white rot disease (*Sclerotium cepivorum*) is a serious production problem throughout the world. Very low pathogen level in the soil can cause significant loss. Generic integrated pest management programs include clean seed, site selection, sanitation, crop rotation, biological and chemical controls, crop resistance to the pest, and other components. Onion white rot disease management currently does not have crop resistance as a component. The lack of resistant germplasm and/or the inability to identify and screen potentially resistant germplasm are primary reasons. Research was conducted to determine if field screening for resistance is feasible, to define field screening methodology, and to identify and/or quantify resistance. Disease incidence was inconsistent from year to year. In some years, disease expression was high; in others, disease was low. Uniform pathogen level and disease expression throughout the experimental field were required for successful screening. Results provide evidence that "resistant" or "tolerant" germplasm does exist, and that disease "resistance", "tolerance", or "susceptibility" can vary from slight to strong, suggesting multigenic involvement. "Resistance"/"tolerance" was identified in long-day yellow hybrids and inbreds. 'Southport White Globe' selections and derivatives had much higher disease susceptibility than yellow or brown skin lines screened.

504

Genetic Analysis of Chinese Cucumber Collections in the U.S. National Germplasm Collection

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Genetic variation in cucumber accessions from China was assessed by examining variation at 21 polymorphic isozyme loci. Principal component analysis of allelic variation allowed for the depiction of two distinct groupings of Chinese accessions collected in 1994 and 1996 (67 accessions). Six isozyme loci (*Gpi*, *Gr*, *Mdh-2*, *Mpi-2*, *Pep-gl*, and *Pep-la*) were important in elucidating these major groups. These groupings were different from a single grouping of Chinese 146 accessions acquired before 1994. Allelic variation in Chinese accessions allowed for comparisons with other accessions in the U.S. National Plant Germplasm System (U.S. NPGS) collection grouped by continent and sub-continent. When Chinese accessions taken collectively were compared with an array of 853 *C. sativus* U.S. NPGS accessions examined previously, relationships differed between accessions grouped by country or subcontinent. Data indicate that acquisition of additional Chinese and Indian cucumber accessions would be strategically important for increasing genetic diversity in the U.S. NPGS cucumber collection.

505

Taste and Quality of Burpless and Bitterfree Cucumbers

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Burpless cucumbers (*Cucumis sativus* L.) are listed in many seed catalogs as being milder for eating than the standard American slicing type. It has been suggested that burpless cucumbers 1) are genetically bitterfree, 2) cause less burping when eaten, or 3) are the marketing term for Oriental trellis cucumbers. The objective of this experiment was to determine whether burpless cucumbers are bitterfree, and whether they cause less burping when eaten. Bitterness of

the plants was determined by tasting a cotyledon of six seedlings per cultivar. Burpiness of the fruits was determined in the field using two seasons (spring and summer) and two replications. Six judges evaluated three cultivars over two harvests by eating one half of a fruit of the three cultivars on three consecutive days (in random order). Burpiness was rated 0 to 9 (0 = none, 1–3 = slight, 4–6 = moderate, 7–9 = severe). 'Marketmore 76' and 'Tasty Bright' were normal-bitter, and 'Marketmore 80' was bitterfree. Burpiness ratings were not significantly different for 'Marketmore 76' (3.0), 'Marketmore 80' (2.6), and 'Tasty Bright' (2.5). Burpless cucumbers appear to be the American marketing term for Oriental trellis cucumbers.

119 ORAL SESSION 27 (Abstr. 506–512)

Vegetable Crops—Culture & Management

506

Findings from a Three-year Crop Nutrient Study with Four Vegetable Crops in Dade County, Florida

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A 3-year replicated fertility trial with four vegetable crops was begun in the 1993–94 season to: a) determine crop nutrient requirements for four vegetable crops (bush bean, malanga (*Xanthosoma caracu*), potato, and sweet corn, and b) to develop and calibrate a soil testing procedure for the local calcareous soils. Soils were found to test medium to high for both phosphorus and potassium. Responses to nitrogen varied by crop. Specific results and follow up trials with growers will be discussed.

507

Presidedressing Soil Nitrate Testing (PSNT) Effective in Reducing N Fertilizer Use in Vegetable Production

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The utility of PSNT in determining N sidedress requirement of cool-season vegetables (broccoli, cauliflower, celery and lettuce) was evaluated in a total of 20 trials conducted in commercial fields in California in 1996–97. Fields were selected which had soil NO₃-N concentration >20 mg·kg⁻¹ at the time the cooperating grower made the first sidedress N application. The grower's fertility program was compared with two reduced N treatments, established by skipping either the first, or the first and second, sidedress N application. There were four replications of each N treatment, in a randomized block design. All fields were conventionally irrigated (sprinkler and/or furrow). Crop and soil N status was evaluated throughout the season. No yield or quality differences were observed in any field by skipping the first N sidedress; in only three fields was yield reduced by skipping two sidedress applications. Total crop N uptake varied little among N treatments in most fields, despite differences in seasonal N application of as much as 200 kg·ha⁻¹. These results indicate that PSNT can reliably identify fields in which sidedress N application can be delayed or eliminated. A soil NO₃-N "quick test" was evaluated and proved to be a practical on-farm method to determine soil NO₃-N status.

508

Cauliflower Microshoots—A Potential Alternative to F₁ Hybrid Seed?

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Cauliflower is produced all year round in the United Kingdom, with winter production confined to relatively frost-free areas such as Cornwall in the south-west peninsula. Most production zones now take advantage of F₁ hybrid varieties although winter production a complete suite of varieties is not yet available and growers must rely on open-pollinated varieties bred locally, which, although being variable, do have locally adapted resistance to prevalent wet weather diseases

such as a *Mycosphaerella brassicae* (ringspot). Micropropagation of cauliflower is well-established and is used routinely by many breeding companies of both F₁ and OP varieties for multiplying clones of parental lines. It is clear however, that the true micropropagation potential of cauliflower has never been realized since the curd has been estimated to bear up to 5 million meristems (Kieffer et al., 1997), yet yields of shoots per head are typically 10 to 100 plants. A new micropropagation schedule for cauliflower has recently been described (Kieffer et al., 1996; Kieffer et al., in press), and it is clear that this schedule does offer a new technology for production of many thousands of plants from a single curd. This paper will explore the potential of the technique as an alternative to F₁ hybrid seed for growers particularly focusing on the limiting processes in the schedule and its cost-effectiveness.

509

Comparison of Mother Stalk Culture and Clear-cut Harvesting for Spring Production and Forcing in Late Summer

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Short lifespan is a major problem with asparagus grown in coastal South Carolina. The Taiwanese system of mother stalk culture may enhance asparagus longevity and yield. The objective was to determine if mother stalk culture improves survival and yields in the spring harvests or late summer forcing compared to conventional spring clear-cut harvesting or to non-conventional forced clear-cut summer harvesting. 'Jersey Giant' asparagus was harvested for 3 years (1993–1996) using: 1) SCC—spring clear-cut (normal emergence in February in this location), 2) SMSuM—spring mother stalk followed by summer mother stalk (mow fern in August and establish new mothers), 3) SM—spring mother stalk only, 4) SuCC—summer clear-cut only (mow fern in August and harvest), and 5) SuM—summer mother stalk only. All mother stalk plots produced 40 mother stalks per 12 m of row length before harvesting. All plots were harvested for 8 weeks. Traditional SCC yielded poorly for a 3-year total of 1,651 kg/ha with a 94% stand reduction after 3 years. SM yielded only 793 kg/ha for all years with a 98% stand loss. SMSuM yielded 1985 kg/ha total for 3 years with an 81% stand loss. SuCC yielded 4073 kg/ha for 3 years with 43% stand loss. SuM yields and stand loss were similar to SuCC. Stand loss in an unharvested controls was 34%. Mother stalk culture did not improve longevity any time. Spring harvesting systems failed because by mid summer, aged fern depleted crown carbohydrates and repeated yearly, this eventually killed the plants. Summer forcing removed aged fern just about the time the fern became inefficient and new efficient fern produced sugars for root storage well into the fall, making recovery successful and sustaining plant longevity compared to traditional spring harvesting.

510

Precision Planting for *sh2* Sweet Corn Stand Establishment

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The impact of soil type and planting depths on the emergence of three hybrids of *shrunken 2* sweet corn with varying seed vigor was investigated. Two field trials were completed (planted on 18 Sept. 1996 and 6 May 1997) in a field containing Crosby and Kokomo soil types in Columbus, Ohio. Three *sh2* hybrids ('Starship', 'Skyline', and 'Confection') were planted at 1.3-, 2.5-, and 5.1-cm depths with six replications on each of the two soils in the fall study. The same hybrids were planted the following spring with an adjustment to 2-, 4-, and 6-cm planting depths over the same soil types, and the addition of a transition soil. The use of data loggers in 1997 allowed for continual monitoring of soil temperatures at each of the planting depths throughout the field, and calculation of soil heat units throughout the emergence period. There were no significant differences between depths for average temperatures or soil heat units. Minimum temperatures were significantly colder on the lighter color soil and had a linear relationship with emergence counts. Soil tests were carried out at all sites for P, K, Mg, and Ca. Although significant differences were found with the Kokomo soil having higher nutrient levels than the transition or Crosby soil, levels throughout the field were more than adequate for emergence. Compaction and soil moisture measurements were taken with a neutron probe. Dry density was significantly higher on the lighter color soils, while soil moisture percentage climbed from 18% on Crosby to 25% on the Kokomo. In both years, there were significant differences in emergence indices based not only on hybrid and planting depth but also on location. Emergence ranged from below 50% to nearly 100% depending on the treatment and field location. Each of the 108 sampling points was located with a GPS receiver

and the use of ArcView software allowed for data layers to be stored and mapped so that prescriptions could be made for best stand establishment.

511

Seed-piece Spacing Influences Yield, Size Distribution, Net Returns, and Stem and Tuber Density of Three Processing Potato Cultivars

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Seed-piece spacing is an important economic consideration in the production of potatoes and optimum varies by cultivar and intended market. A study was designed to determine the influence of seed-piece spacing on yield, tuber size distribution, net returns and stem and tuber density of three processing potato cultivars. Seed tubers of cvs. Russet Burbank, Frontier Russet and Ranger Russet were planted 8, 15, 23, 31, 46, 61, 76, or 91 cm apart at two locations in 1988 and 1989. Total, marketable (U.S. No. 1), and mid-size (226–452 g tubers) yield, yield of five incremental size categories, net profits from a typical processing contract, and stem and tuber density (number per m of row) were determined. All three cultivars achieved highest total yields at the narrowest (8 cm) spacing. Marketable and mid-size yield were optimized between 15 and 31 cm depending on the cultivar. The size distribution of tubers shifted from a predominance of small tubers at the narrow spacing treatments to a predominance of large tubers at the wide spacing treatments. The rate of shift across spacing treatments was cultivar dependent. Russet Burbank showed a bimodal response to spacing for net returns with optimums at the 23- and 46-cm spacing treatments. Frontier Russet and Ranger Russet showed optimums at 23 cm. All three cultivars gave maximum mid-size yields at a stem density of 10.5–12.1 per m of row and a tuber density of 23.9–24.9 per m of row.

512

Effect of In-row Plant Spacing on Yield of 'Beauregard' Sweet-potato

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Several in-row plant spacings (15, 23, 31, and 38 cm) of 'Beauregard' sweet-potato [*Ipomoea batatas* (L) Lam.] were evaluated to determine which spacing produced higher yields under North Carolina growing conditions. The 15 cm spacing (the closest spacing evaluated) gave the highest root yields. With closer plant spacings, the yields of No. 1 grade roots increased compared to wider plant spacings. The No. 1 grade is the most desired and gives the grower the greatest monetary return. Jumbo grade root production increased with wider plant spacings due to less plant-to-plant competition compared to those at closer spacings. In most cases, the widest spacing tested for 'Beauregard' (38 cm) produced lower yields (except for jumbo grade yields) to the other spacings tested.

120 ORAL SESSION 28 (Abstr. 513–520) Floriculture—Postharvest/Growth & Development

513

Hormone Sprays and Supplemental Light Prevent Cold-storage-induced Postharvest Leaf Chlorosis and Abscission in 'Stargazer' Hybrid Lilies

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Rapid leaf chlorosis and abscission limits the use of cold storage for post-production short-term holding of potted lilies. We investigated the effects of storage temperature, storage irradiance and pre-storage foliar sprays of gibberellin and/or cytokinin on postharvest leaf and flower quality of *Lilium* sp. 'Stargazer' hybrid lilies. Storage of "puffy bud" stage plants at 4, 7, or 10 °C in dark for 2 weeks induced leaf chlorosis within 4 days in a simulated consumer environment, and resulted in 60% leaf chlorosis and 40% leaf abscission by 20 days. Cold-storage also reduced the duration of flower bud opening, inflorescence

and flower longevity, and increased flower bud abortion. Providing light up to 40 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ during cold-storage at 4 °C significantly delayed leaf chlorosis and abscission and increased the duration of flower bud opening, inflorescence and flower longevity. Foliar sprays of ProVide (100 $\text{mg}\cdot\text{L}^{-1}$ GA₄₊₇) and Promalin [100 $\text{mg}\cdot\text{L}^{-1}$ GA₄₊₇ and 100 $\text{mg}\cdot\text{L}^{-1}$ benzyladenine (BA)] effectively prevented leaf chlorosis and abscission at 4 °C, while ProGibb (100 $\text{mg}\cdot\text{L}^{-1}$ GA₃) and ABG-3062 (100 $\text{mg}\cdot\text{L}^{-1}$ BA) were not effective. Accel (10 $\text{mg}\cdot\text{L}^{-1}$ GA₄₊₇ and 100 $\text{mg}\cdot\text{L}^{-1}$ BA) showed intermediate effects on leaf chlorosis. Flower longevity was increased and bud abortion was prevented by all hormone formulations except ProGibb. The combination of light (40 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) and Promalin (100 $\text{mg}\cdot\text{L}^{-1}$ GA₄₊₇ and 100 $\text{mg}\cdot\text{L}^{-1}$ BA) completely prevented cold-storage induced leaf chlorosis and abscission and significantly improved flower opening and overall plant quality.

514

Effect of the Stages of Floral Development and Postharvest Temperatures to Flowering of *Eremurus* in Israel

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The influence of postharvest temperature on the flowering response of *Eremurus* was studied. The plants were harvested at four different stages of development and were separated into three groups. The first group was immediately exposed to 2 °C, the second group to 20 °C followed by 2 °C, and the third group to 20 °C followed by 32 °C and, subsequently, 2 °C. Scanning electron microscopy (SEM) was used for concurrent morphological analysis of floral development. Application of 2 °C to the plants in the initial stage of floral development caused plant destruction and death, while the same treatment applied at the stage of full differentiation promoted normal flowering. Temperatures of 20 °C and, especially, 32 °C, significantly improved flowering of the plants harvested in the early stages of florigenesis, whereas the same treatment applied to the plants harvested at the end of flower differentiation did not affect the flowering process. A developmental disorder, which we term "Interrupted Floral Development" (IFD), was observed only in the plants harvested when the racemes were fully differentiated. This was probably caused by the very high air and soil temperatures that prevail in Israel during the summer. The extent of floral differentiation has a determinant role in subsequent scape elongation and flowering.

515

Photoperiod Affects Growth, Dry Weight and Fructan Partitioning in Dahlia 'Sunny Rose' Seedlings

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Photoperiod can be an important environmental variable for dahlia seedling (plug) production. During a 7 week plug production scheme, long days provided by a 4-h night interruption with ≈ 10 fc of incandescent light inhibited tuberous root development while increasing shoot fresh and dry weight, fibrous root dry weight, leaf area, and height. Night interruption reduced plug production time by 1 to 2 weeks and plugs grown under long days showed superior growth following transplanting to 10-cm pots. No significant difference in total plant fresh and dry weight was observed between long-day and short-day plugs, indicating that growth differences were a result of photoperiod alterations in carbohydrate partitioning. Tuberous roots of short-day-grown plugs showed a 156% increase in fructan concentration (mg/g dry wt. basis) over long-day plugs. The carbohydrate status of long-day (night interruption) tuberous root tissue was characterized by high glucose concentration. The accumulation of glucose (a product of fructan synthesis), in plugs grown with night interruption is believed to be the result of slower rates of cell wall formation in long-day plugs compared to short-day plugs. HPAEC-PAD separation of fructans showed a maximum degree of polymerization of ≈ 30 in short-day tuberous roots and 27 for long-day tuberous roots. Effects of photoperiod on fructan metabolism in dahlia tuberous roots and the practical use of photoperiod in dahlia plug production are discussed.

516

Zantedeschia aethiopica and Z. 'Green Goddess' Responses to GA₃ and Bonzi for Cut Flower Calla Lily Production in Florida

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Zantedeschia aethiopica, the large white calla lily, and Z. 'Green Goddess', which is white with a unique green blush on the lip, are two cultivars popular in the floral cut flower trade. Both were treated with gibberellic acid (GA₃) for increased

flower development, a technique routinely successful for potted calla production but not previously reported effective on cut flowers. Two winter trials in successive years were replicated under Florida growing conditions. A preplant bulb dip of GA₃ ranged from 100 to 250 ppm. *Z. aethiopica* control plants averaged 1.3 flowers per plant, which increased to 3.4 with GA₃ in the first trial and from 1.6 to 2.5 in the second trial. 'Green Goddess' went from 1.3 to 3.8 flowers per plant and 0.9 to 3.3, respectively. Bonzi was applied at either a short (10.2–12.7 cm) or tall (30.5–38.1 cm) height, with greater effect when shorter. A drench application of 2 mg a.i. per pot shortened foliage more than flower height with 32% reduction on foliage and 12% on flowers for *Z. aethiopica* and 44% and 33% respectively on 'Green Goddess'. Results favor use of GA₃ on cut flowers for increased flower production, but discourage Bonzi because shortened heights are normally undesirable for cut flowers.

517

Floral Ontogeny of *Pelargonium xdomesticum*

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Floral ontogeny of *Pelargonium xdomesticum* was examined for two cultivars grown under identical environmental conditions. Apical meristems of 'Duchess' and 'Jennifer' were vegetative at the commencement of the experiment. Meristems were examined every five days over an experimental period lasting 85 days. Floral ontogeny was the same for both cultivars, although the timing of floral initiation of the meristem, floral organ initiation, and floral organ development differed. The vegetative meristem was convex with leaf primordia initiated on either side in an alternate pattern. Early floral initiation was characterized by formation of a cleft towards one side of the meristem, followed quickly by a second cleft on the other side. Between the clefts new meristems developed. New meristems lacked leaf primordia. Proliferation of meristems continued until numerous meristems were organized in a cluster arrangement at the apex of the shoot. Proliferation of meristems at the apex continued until multiple inflorescences had developed. Inflorescences were subtended by bracts. Floral organ primordia were initiated in a succession of four whorls: sepals, petals, androecia and gynoecium. Petals and androecia appeared to develop simultaneously soon after sepal primordia were visible. Petal primordia remained small while the androecia continued to grow. The gynoecium first formed a conical shape, with carpels protruding from the base in a bulbous fashion. At the distal end of the gynoecium, divisions appeared which developed into stigmatic lobes. As the gynoecium elongated, stigmatic lobes became more pronounced. Petal elongation concurred in synchrony with elongation of the gynoecium. On one experimental unit of 'Duchess' two florets had opened at 750 total cumulative moles. No 'Jennifer' florets had opened by termination of the experiment.

518

Occurrence and Development of a Dorsal Gland in the Leaves of Twelve Cultivars of *Ficus benjamina* L. (Weeping Fig)

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Ficus benjamina plants are an integral part of most modern interior landscapes. Reports from growers and interiorscape managers have drawn attention to a specific problem related to large *F. benjamina* plants, namely the occurrence of a dark oval spot on the abaxial surface of the leaf base. Twelve cultivars of *F. benjamina* were examined: Christine, Citation, Florida Spire, Kelly, Kiki, Midnight, Monique, Stacey, Wintergreen, Dwarf Nikita, Spearmint, and Starlight. Anatomically, the dorsal gland consisted of one to several layers of densely stained, columnar cells. Positive colorimetric reaction for phenolics was obtained in the glandular cells. Developmentally, the gland cells could not be distinguished from the regular epidermal cells until ~30% of final leaf size was reached. The cells of the outermost glandular layer changed shape from rectangular with long axis parallel to the leaf surface to elongate with long axis perpendicular to the surface. In a mature leaf, the thickness of the glandular layer was between 20 and 30 µm. Externally, at this stage, no dark spot, indicative of the gland's location, could be observed. In older leaves, however, an accumulation of phenolic substances led to appearance of dorsal dark spot. All cultivars possessed glandular layer. However, this area did not darken in all cultivars; Christine, Citation, Florida Spire, Kelly, Kiki, and Stacey developed small dark spots, while Dwarf Nikita and Starlight had numerous, well-pronounced glandular regions. This study showed that the dark

spots in *F. benjamina* cultivars were a normal morphological feature. Although the gland was present in every cultivar, only a few cultivars developed a dark color.

519

Calcium Oxalate Cuticular Crystals in the Epidermis of *Dracaena*—A Taxonomic Feature of the Genus

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The genus *Dracaena* has been placed in Agavaceae by most taxonomists. Recent work, however, has justified the placement in a separate family, Dracaceae. This study was initiated to examine the extracellular crystalline deposits in *Dracaena* and the possibility of this feature as a taxonomic trait of the genus. Fresh epidermal peels of five *Dracaena* species were observed under polarized light. Extracellular epidermal crystals were evident in all of them. The deposits were found between the cuticle and the outer primary epidermal cell wall. The crystal size varied from less than 1 µm to 5 µm along the long crystal axis. The size and quantity of the deposits varied between the species with largest and most numerous crystals in the cuticle of *D. marginata* and *D. sanderiana*. *Dracaena deremensis*, *D. fragrans*, and *D. surculosa* had smaller and less numerous crystals. The optical properties of the crystals were indicative of calcium oxalate monohydrate form which exhibited interference colors of second and third order. For comparison species of three members of Agavaceae were examined - *Cordylone terminalis*, *Sansevieria trifasciata*, and *Yucca sp.* No extracellular crystal deposits in the proximity of the epidermal wall were detected. Based on our observations, the genus *Dracaena* possessed an anatomical feature which could be used for identification. The existence of calcium oxalate crystals embedded in the cuticle was readily observable in fresh epidermal peels under polarized light.

520

Effects of Irradiance Levels during Flasking and Greenhouse Production on Growth and Flowering of the Phalaenopsis Orchid

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Four-month-old, aseptically raised Phalaenopsis Arien Kaala 'TSC 22' seedlings 1.0 cm in leaf spread were transferred (Nov. 1995) 25 per polycarbonate box to an agar medium and placed under 10, 20, 40, or 80 mol·⁻²·s⁻¹ PPF from cool-white fluorescent tubes. In June 1996, plants grown under 40 or 80 mol·⁻²·s⁻¹ PPF had greater mass, wider leaves, and more roots than those under the two lower PPF. Plants were then transplanted and grown in a greenhouse (GH) under 340, 170, or 85 mol·⁻²·s⁻¹ maximum PPF. In May 1997, plants previously produced under 40 mol·⁻²·s⁻¹ PPF had longer, wider, and thicker leaves than those under 10 mol·⁻²·s⁻¹ PPF when grown under the two higher GH PPF. Under the low GH PPF, however, plants were equally small, regardless of the previous flasking PPF levels. Plants under the high, medium, and low GH PPF had an average of 61, 37, and 17 g of fresh mass, respectively. By September 1997, plants had increasingly larger leaves and higher concentrations of malic acid, sugars, and starch as GH PPF increased. Each doubling in GH PPF resulted in more than a two-fold increase in plant fresh mass. Under the low GH PPF, plants previously produced under 80 mol·⁻²·s⁻¹ PPF during flasking were 13% larger than those under 10 mol·⁻²·s⁻¹ PPF. Plants grown under the high, medium, and low GH PPF had 100%, 79%, and 0% flowering, respectively. Those under the high GH PPF bloomed earlier and had longer inflorescences, bearing many more and larger flowers, than those under the medium GH PPF.

121 ORAL SESSION 29 (Abstr. 521–528)

Small Fruit—Crop Production/Physiology

521

Strawberry Transplant Propagation in Elevated Horizontal Troughs

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Commercial strawberry cultivars are vegetatively propagated in field nurseries. Mother plants produce daughter plants on stolons in response to long photo-

periods and high temperatures. The daughter plants are primarily removed from the field as a bare-root transplant. These bare-root transplants can be extremely stressed in this digging process, resulting in plant variability and pathogen infestation. A strawberry transplant production system has been developed that uses micropropagated disease free mother plants in elevated horizontal culture. The mother plants are grown in suspended plastic troughs (10-cm width by 10-cm depth) with a soilless medium consisting of vermiculite and perlite. The mother plants are subfertigated via drip tubing to avoid leaf wetness. Stolons produced by the mother plants hang over the trough and continue to grow down toward the ground. The stolon tips, are harvested and rooted in plug trays. This study compared proliferation rates of several strawberry cultivars. The benefits of the elevated system were: disease-free plants, high-density daughter plant production, all the runners could be removed at one time and separated for propagation, and the daughter plants had active root tips that established quickly.

522

Factors Influencing Strawberry Plug Plant Performance

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Three studies evaluating production of strawberry (*Fragaria x ananassa* Duch.) plug plants were conducted. The influence of runner tip plantlet size, container size, and chilling on the field performance of 'Chandler' plug plants were evaluated over a 2-year period in central and southern Alabama. Plantlet size did not significantly influence yield following transplanting; therefore, grading of plantlets prior to propagation appears to be an unnecessary expense for successful yields from plug plants. There were no significant differences in yields of plug plants from 60-cell vs. 72-cell packs; therefore, growers could produce more plug plants in the same area without compromising total yield, early yield, or berry size when propagating plug plants in 72-cell packs. The influence of 1, 2 or 3 months of runner tip cold storage prior to rooting in cell packs was also investigated.

523

Soil Moisture and Soil Salinity Distribution in Strawberry Beds

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Strawberries in the Santa Maria Valley are grown on beds 25.2 cm wide with four rows of strawberries and two lateral drip tapes. Previous strawberry production was on beds 15.7 cm wide with two rows of strawberries and one lateral drip tape. The two strawberry production systems were evaluated on several grower fields for water emission uniformity, soil moisture, and soil salinity. The salinity was evaluated for placement in the bed, type of salts, and nitrate concentration. At one side, the effect of banded slow-release nitrogen fertilizers as a source of nitrogen in addition to that applied through fertigation was investigated. Results showed that the EUs ranged between 80% and 96%, with an average of 89%. A variety of distributions were found for soil moisture, soil salinity, and soil nitrate, depending on the water and fertilizer management and time of sampling with respect to irrigation and fertigation. Distributions of soil moisture content made 3 to 4 days after an irrigation indicated excessive drying of the soil between irrigations. Distributions of soil salinity revealed high salt concentrations near the drip tape, where leaching was insufficient, and relatively low concentrations near the tape, where leaching was adequate. Nitrate concentrations in and below the rootzone were smaller where no slow-release fertilizers were used.

524

Phenological Aspects of Strawberry Growth Influencing Gray Mold Development in Annual Systems

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Strawberry (*Fragaria x ananassa*) plant phenology was evaluated at two sites in North Carolina in order to assess the relationship of plant growth and the development of gray mold fruit rot (*Botrytis cinerea*). Site 1 consisted of three cultivars: Camarosa (CA), Chandler (CH), and Sweet Charlie (SC) from a single nursery; site 2 consisted of cultivar CH obtained from three distinct sources. Weekly records were kept of leaf senescence, leaf emergence, flowering, and fruit set, as well as a monthly whole-plant analysis. Leaf senescence and emergence was uniform for all treatments, with >90% of transplant foliage senescing between November

and December. Analysis of leaf area and plant weights reveal an increase in dry mass beginning in February and continuing through April. Although first bloom appeared in December, primary floral development occurred in late February for cultivar SC and in March for cultivars CA and CH, with blooms continuing through late May. Marketable yield was lower in cultivar SC throughout harvest, with the exception of early fruit development in March. Non-marketable yield varied, with increases in gray mold following periods of heavy rainfall. Statistical analysis of all data shows no consistent differences in plant growth or disease among treatments. Analysis of foliage revealed latent infections on transplants as the primary source of gray mold inoculum. Patterns of plant growth and corresponding disease development found in this study provide tools necessary for phenology-based control practices for the integrated management of gray mold.

525

Chill Requirements to Break Dormancy of Wisconsin Cranberry: Conventional Models may Not be Applicable

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Conventional chilling models developed primarily for deciduous fruit crops such as apple and peach are based on the accumulation of optimal chilling temperatures between ≈ 4 and 7 °C. Cranberry (*Vaccinium macrocarpon*) is a perennial evergreen woody vine that requires chilling temperatures to overcome its dormancy. Periodic collections of budded stems (uprights) from cranberry beds (cv. Stevens) in central Wisconsin throughout the fall and early winter were forced to determine when dormancy requirements were met in the field. For this purpose excised uprights were placed in deionized water in test tubes at 24 °C and 16-h day (cool-white fluorescent). In both 1996 and 1997 it was observed that uprights were able to break bud and grow in late fall and early winter only after experiencing (in addition to chilling) a prolonged period of temperatures slightly below freezing. As an evergreen plant, cranberry may be receiving critical environmental cues at its leaves. Additionally, the existence of the native cranberry plant in harsh winter environments may have resulted in the need for freezing temperatures during dormancy to ensure survival.

526

Ripening Stages of Cranberry Fruit Have a Dramatic Influence on Its Postharvest Shelflife: Physiological and Morphological Explanation

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Cranberries ripen in late fall. The fruit develops color in the outer two cell layers in response to low temperatures and incident light. Berries at the top of the canopy generally develop full red color, whereas fruits lower in the canopy (especially under dense canopies) can remain white even at harvest time. This is especially true for Wisconsin-grown cranberries. Wet-harvested cranberries are stored for 1 to 2 months and sold at Thanksgiving and Christmas time. We investigated if the storage quality of fruit is dependent on ripening state. Wet-harvested fruits were sorted into four different ripening stages and rated for quality after 4 and 7 weeks of storage. In addition, fruit CO₂ and ethylene production, as well as anthocyanin content, were measured after 4 weeks of storage. The amount of rotten fruit among red, light red, blush, and white were 12%, 14%, 23%, 38% respectively. Thus, white fruits had three times greater incidence of rot than the red fruits. Although the ethylene production by various categories of fruit was nearly same, white fruits had 70% higher respiration than red fruits. We also found that as the fruit developed color cuticle thickness increased. For example, cuticle thickness averaged 1.6 μm for white fruit and 2.3 μm for red fruit. In addition, the calyx end opening of red fruit was impregnated with more wax than white fruit. Furthermore, a compact cell layer accumulated anthocyanin under the calyx opening in red fruit only. Our studies suggest that white berries have poor shelf-life as compare to red fruit because: i) white fruits have higher respiration rates, ii) thicker cuticle and wax accumulation (especially at the calyx end) on red fruits retard the entry of microorganisms into the fruits during wet harvest.

527

Sepal Color Change Relates to Fruit Quality, Firmness, and Detachment Force in Erect and Semi-erect Thornless Blackberry Cultivars

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Black coloration occurs before the inception of horticultural maturity, so other cues (sheen, drupelet shapes, drupelet sizes, and fruit detachment force) have been employed as indicators of physiological and horticultural maturity among erect and semi-erect thornless blackberry cultivars. A more distinct visual cue might, however, allow reductions in the variability of quality, firmness, and shelflife among manually harvested berries. Such a maturity indicator would allow researchers to select more-uniform materials for genetic and physiologic studies of blackberry fruit ripening and quality development. Our 1996 and 1997 data confirm earlier observations of sepal color relationships to fruit quality attributes (soluble solids, pH, titratable acidity, and sugar/acid ratio) among semi-erect cultivars, and they show that such relationships exist among erect cultivars. These data also demonstrate relationships among sepal color, fruit detachment force, and berry firmness in both phenotypes.

528

Control of Weeds, Insects, and Diseases on Cranberry with a Spring Flood

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An intensive study of the use of spring flooding to control pests and reduce chemical inputs in cranberry production began in 1995, following preliminary studies in 1993 and 1994. This 4-week flood, known as late water (LW), has been shown to suppress some insects, mites, and fungi, and to stimulate plant growth. We demonstrated that pesticide use could be reduced or eliminated in the year of the flood and to a lesser extent in the year following the flood. With the use of LW in from 1993 to 1996, cranberry grower participants in our study reduced insecticide sprays by 24% and reduced fungicide applications by 30% compared to standard practice bogs without effect on crop quality. LW increased mortality of *Rubus* sp. weeds so that their spread in a cranberry bed was checked. However, the weed population did not decrease over time. Effects of the flood on cranberry growth and productivity were examined. With changes in rate and timing of fertilizer inputs, growth was similar to that on control beds. However, following an abnormally mild winter and drought conditions in 1995, crops on LW bogs were reduced, sometimes severely, compared to the controls. Crop was not affected in 1993, 1994, or 1996. On a LW bog, it is possible to reduce insecticide use by up to 60%, fungicide use by up to 50%, and nitrogen use by 30%. Reductions and outcomes vary depending on seasonal conditions but, with careful management and weather monitoring, this practice remains a strong option for a sustainable cranberry production system.

130 ORAL SESSION 30 (Abstr. 529–535) Woody Ornamentals/Landscape/Turf— Stress Physiology

529

Photosynthesis and Growth of *Magnolia x soulangiana* in Response to Consecutive Drought Stress

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Responses of *Magnolia x soulangiana* 'Jane' to consecutive short-term drought stresses were evaluated in this study. Plants were received from a commercial nursery in 19-L containers in a 4:1 pine bark:sand media. In Oct. 1997, plants were exposed to one, two or three consecutive 3-day drought stress periods, each separated by one rewatering period. There were 48 total plants with eight replicates per treatment for each stress period. Following each stress period, a group of eight control and eight stressed plants were planted in the field and well-watered to monitor recovery from each stress duration. Whole-plant photosynthesis, leaf photosynthesis, shoot growth, and soil moisture content were measured approximately every 2 days during the stress periods. Leaf photosynthesis, shoot growth,

and leaf defoliation rate were monitored for recovering plants. Few differences in growth were noticed except more rapid defoliation with onset of autumn for the three 3-day stressed plants. Whole-plant and leaf photosynthesis were reduced by day 3 of the first 3-day stress for drought-stressed plants and remained lower while plants were under stress. After release from stress, photosynthesis returned to control levels for plants receiving one and two 3-day stress treatments in ≈ 1 week, while it was more than 3 weeks until recovery for plants receiving three 3-day stress treatments. Plants will be evaluated in Spring 1998 for bloom and growth characteristics.

530

The Influence of Drought on Growth and Gas Exchange in *Fraxinus* species

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Fraxinus americana, *F. pennsylvanica*, and *F. nigra* were subjected to short-term drought of 4, 8, and 16 days. Seedlings were obtained from a commercial nursery and grown in 4:1 pine bark:sand media for 3 months prior to the onset of the stress. Seventy-two trees with six replicates per stress treatment were arranged in a completely randomized design. Following each stress period, the appropriate trees were well watering and monitored through recovery. Leaf photosynthesis, shoot growth, leaf emergence, terminal bud set, trunk caliper and soil moisture content were measured through the stress and recovery periods. Drought suppressed shoot growth and leaf emergence in all species; however, Green Ash maintain active growth at higher rates than either White or Black. Leaf photosynthesis was reduced in both White and Black following 4 days of drought whereas Green ash was not adversely effected until day 10. Trees were harvested following recovery and dry weight fractions of leaves, stems, and roots recorded.

531

Effect of Biostimulants on Drought Tolerance of Ornamental Annuals

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This study determined the effect of the granular humate Earthgreen (Menefee Mining Corp., Dallas) and the biostimulant ROOTS2™ (LISA Products Corp., New Haven, Conn.) on drought tolerance of the ornamental annuals *Impatiens wallerana* 'Accent White' and *Salvia splendens* 'Red Hot Sally'. Earthgreen was incorporated into the soil and ROOTS2™ applied as a root drench at transplanting and 30 days after transplanting. Transplants were established in greenhouse beds under irrigated conditions for 8 weeks, then subjected to a five week drought. Data indicates rates of 43.9 and 87.9 g·m⁻² of Earthgreen or 300 ml of 1% or 2% ROOTS2™ per plant had no significant effect on *Salvia* shoot dry weight or chlorophyll content of *Salvia* or *Impatiens* at the end of the 8-week establishment period. However, *Salvia* flower dry weight was significantly increased with the higher rate of Earthgreen. During the 5-week drought, Earthgreen or ROOTS2™ did not significantly affect xylem pressure potential of *Salvia* or relative water content of *Impatiens*. After the 5-week drought no significant effect of either product on shoot dry weight of *Salvia* or *Impatiens* or flower dry weight of *Salvia* was observed.

532

Effects of Drought and Post-drought Recovery on Katsura Tree

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Katsura tree (*Cercidiphyllum japonicum* Sieb. & Zucc.) is appreciated because of its stately form and brilliant autumnal leaf color. One problem of the species, however, is its reputed intolerance to drought. While data either refuting or substantiating this claim are lacking, anecdotal references abound. To understand this issue better, a study was designed to measure the effect of drought and post-drought relief on growth and development of katsura. Two-year-old trees were container-grown in a greenhouse and subjected to one of three irrigation treatments (comprised of four irrigation phases) that simulated either drought or conditions where moisture was not limiting. In treatment one (control), plants in each phase were irrigated daily with the amount of water lost the previous 24 h. Plants in the second treatment experienced an initial drought phase (irrigation

withheld until soil moisture content decreased to a predetermined level) followed by three non-drought phases. In the third treatment, plants were subjected to two drought phases, each followed by a non-drought phase. Destructive harvests were performed at the beginning of the study and at the conclusion of each phase. Due to abscission, trees subjected to one and two drought phases underwent a 38% and 63% reduction in lamina mass, respectively. Stem diameter in trees exposed to both drought phases was 16% less than that of controls. Net assimilation rates of trees within each treatment indicate that plants recovering from drought may be more efficient as assimilating systems than controls. Based upon our results, we find that katsura is a drought avoider, responding to drought by defoliating. Refoliation once water is available does occur and may lend itself to recovery.

533

The Effects of Drought on Leaf Gas Exchange and Growth of Three Species of Herbaceous Perennials

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Three species of herbaceous perennials were tested on their ability to withstand and recover from drought stress periods of 2, 4, and 6 days. *Eupatorium rugosum* and *Boltonia asteroides* 'Snowbank' were chosen because of their reported drought intolerance, while *Rudbeckia triloba* was chosen based on its reported drought tolerance. Drought stress began on 19 Sept. 1997. Plants were transplanted into the field the day following the end of each stress period. The effects of drought on transpiration rate, stomatal conductance, and net photosynthetic rate were measured during the stress and throughout recovery using an infrared gas analysis system. Leaf gas exchange measurements were taken through recovery until there were no differences between the stressed plants and the control plants. Transpiration, stomatal conductance, and photosynthesis of *Rudbeckia* and *Boltonia* were not affected until 4 days after the start of stress. Transpiration of *Eupatorium* decreased after 3 days of stress. After rewatering, leaf gas exchange of *Boltonia* and *Rudbeckia* returned to non-stressed levels quicker than *Eupatorium*. Growth measurements were taken every other day during stress, and then weekly following transplanting. Measurements were taken until a killing frost that occurred on 3 Nov. There were no differences in the growth between the stressed and non-stressed plants in any of the species. Plants will be monitored throughout the winter, spring, and summer to determine the effects of drought on overwintering capability and regrowth.

534

Transplanting Shock and Water Relations in Urban Tree Species

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Large-caliper trees transplanted into urban settings show low survivability. A 1-year transplanting experiment was conducted using *Acer ginnala* and *Acer truncatum*. Trees were blocked by species and size, with three blocks of four trees per species. Three trees of each species were left in their original location for purpose of comparison. A 2 x 2 factorial was used to assign treatments (water, water and top prune, top prune, and transplanted control). Using a Schollander Pressure Bomb, predawn and midday water potential measurements were recorded biweekly from early May through September. The first 8 weeks following transplant, all transplanted trees of both species had significantly ($P \geq 0.05$) more negative midday water potentials than those not transplanted. During periods of stress, predawn water potentials of transplanted trees did not recover overnight. By September, irrigated trees had water potentials not significantly different from those of trees not transplanted. Canopy closure was measured on the same schedule using a Li-Cor Canopy Analyzer. Leaf area index of transplanted trees was nearly half that of non-transplanted trees. Trees treated with water did have slight, but significantly greater leaf area indexes than those of other treatments. It appears that the most notable effect of transplanting is the inhibition of leaf expansion resulting from early spring water stress. This leads to an open canopy for the whole season following transplant.

535

Urban Influences on Local Plant Hardiness Zones

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The combination of concrete, asphalt, large buildings, lack of surface water,

and heat inputs from industry, automobiles, and poorly insulated buildings result in warmer temperatures in urban environments. This effect is most pronounced in winter minimum temperatures and may cause changes in local plant hardiness zone designations. We obtained minimum temperatures for the years 1974–96 from NOAA and the Office of the State Climatologist of Texas for all recording stations in the counties in and immediately adjacent to the Dallas/Fort Worth, Texas (D/FW), metroplex to compare to the 1990 USDA plant hardiness zone map. These data were averaged and analyzed in two groups, 1974–86, which correspond to the 1990 USDA map, and the subsequent years, 1987–96. Stations that did not include a minimum of 15 years of data or anomalies that could be attributed to microclimatic phenomena were discarded. Minimum temperatures were averaged and a contour map was created using TNT Lite software. This map was overlaid on a TIGER map that included county lines and major roadways. The 1974–86 map illustrated only one discrepancy with the 1990 USDA map, the inclusion of 8a temperatures for most of the Tarrant county. Changes in the 1987–96 map included the further expansion of 8a westward into Parker county and an 8b zone in the downtown/Love Field area of Dallas. These changes corresponded well with increased construction and human activity in these areas over the past decade. These changes also help explain variations in low-temperature damage of several ornamental plant species reported in previous studies.

131 ORAL SESSION 31 (Abstr. 536–543)

Fruits—Photosynthesis/Growth & Development/Water Relations

536

Prohexadione-Ca—A New Plant Growth Regulator for Apple with Interesting Biochemical Features

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Prohexadione-Ca is currently developed as an inhibitor of excessive vegetative growth in apple. In addition to the control of shoot growth, distinct effects on the incidence of fireblight are observed that are not due to any bactericidal effect of the compound. Further, the compound often causes a delay of senescence. It is known that prohexadione-Ca acts as a structural mimic of 2-oxoglutarate thereby inhibiting dioxygenases, which catalyze distinct steps in gibberellin (GA) biosynthesis. As a result, levels of growth-active GAs are lowered and, hence, longitudinal shoot growth is reduced. Prohexadione-Ca also induces changes in flavonoid metabolism, which may also be related to the inhibition of dioxygenases involved in this pathway. Preliminary evidence is available that this effect is related to a lowered susceptibility of apple tissue towards infection with fireblight. ACC oxidase, another dioxygenase, which catalyzes the conversion of aminocyclopropane-carboxylic acid into ethylene, is also affected by prohexadione-Ca and related compounds. Lowered levels of ethylene may account for a delay of senescence.

537

Whole Plant Measurement of Photosynthesis and Development of Apple Trees in Relation to Pest Damage

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The objectives of this study were to determine the relationship of whole-plant photosynthesis (WPP) and overall growth of apple trees to the damage caused by insects and disease. This project was part of a larger experiment involving a pest control system consisting of different control strategies, with integrated pest management being one. WPP was measured seven times during the 1997 growing season on 16 single-tree replicates of apple trees from two varieties, 'Empire' and 'Liberty', on M-9 rootstocks at the Clarksville Horticulture Experiment Station. WPP was measured on trees subjected to six pesticide and fungicide treatments that were part of the established study. In addition to these measurements, the leaf number and area were determined at the time of the measurement. At three times during the growing season, an estimation of insect damage to the fruit

and foliage were determined. At harvest, the total number, size distribution, and weight of the apples from each tree was measured. In addition, an estimation of pest and disease damage to the fruit was conducted. Results showed a decrease in the rate of WPP as the season progressed. All of the treatments had higher rates of photosynthesis than the control trees. In addition, the soft chemical treatments had higher rates of photosynthesis than the conventional IPM treatments, 1.8 and 1.5 mmol CO₂/cm² trunk cross sectional area per s, respectively. Further details of these results and the relationships between foliage damage, photosynthesis and tree yield will be presented.

538

Light Absorption and Partitioning in Response to Nitrogen in Apple Leaves

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Bench-grafted Fuji/M26 apple trees were fertigated with different concentrations of nitrogen by using a modified Hoagland solution for 6 weeks, resulting in a range of leaf N from 1.0 to 4.3 g·m⁻². Over this range, leaf absorbance increased curvilinearly from 75% to 92.5%. Under high light conditions (1500 mol·m⁻²·s⁻¹), the amount of absorbed light in excess of that required to saturate CO₂ assimilation decreased with increasing leaf N. Chlorophyll fluorescence measurements revealed that the maximum photosystem II (PSII) efficiency of dark-adapted leaves was relatively constant over the leaf N range except for a slight drop at the lower end. As leaf N increased, non-photochemical quenching under high light declined and there was a corresponding increase in the efficiency with which the absorbed photons were delivered to open PSII centers. Photochemical quenching coefficient decreased significantly at the lower end of the leaf N range. Actual PSII efficiency increased curvilinearly with increasing leaf N, and was highly correlated with light-saturated CO₂ assimilation. The fraction of absorbed light potentially used for free radical formation was estimated to be about 10% regardless of the leaf N status. It was concluded that increased thermal dissipation protected leaves from photo-oxidation as leaf N declined.

539

The Effect of Water Shortage on Potted Peach Trees in Relation to Ecophysiological Parameters and Infra-red Thermometry

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Potted peach trees grown outdoors during the 1997 season were subjected to drought and subsequent rewatering to evaluate their dynamic response to soil water content. The investigation was primarily focused on the early detection of plant water stress to prevent negative effects on the growth. Leaf chlorophyll fluorescence and canopy temperature estimates (by infra-red thermometry) were conducted. Drought effect on physiological processes were detected through by estimates of canopy development rate, leaf gas-exchange measurements; while leaf water potential was measured to characterize plant water status. A decrease in the canopy's development rate was found 1 week after irrigation was stopped, which also coincided with a more-negative leaf water potential, whereas a decrease of the gas-exchange activities occurred several days later. No significant differences between the stressed and control plants were recorded by the chlorophyll fluorescence parameters (F_o, F_m, F_v and the ratio F_v/F_m), whereas the infra-red estimates of canopy temperature detected a slight increase of the canopy surface temperature (connected to the change of leaf energy balance and in relation to partial stomatal closure) on the non-irrigated plants 1 week after the beginning of the trial. The use of infra-red thermometry for early detection of water shortage is discussed.

540

Carbohydrate Metabolism of Vegetative and Reproductive Sinks in the Late-maturing Cultivar Encore

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Activities of major sorbitol and sucrose metabolizing enzymes and carbohydrate contents were followed during the growth season of 'Encore' peach fruits and developing shoot tips. In fruit flesh, sucrose synthase (SS) was present during stage I of growth, when cells are actively dividing, and NAD⁺-dependent sorbitol dehydrogenase (SDH) during stage III, when cells enlarge actively. Acid invertase

(AI) revealed the best correlation with relative growth rate (RGR) of fruits during the entire season. Activities of all carbohydrate metabolizing enzymes were not detectable in fruit flesh during seed filling and pit hardening, when RGR of fruits was the slowest. The highest content of sucrose was in concert with low levels of sucrose metabolizing enzyme activities toward the end of fruit development. In shoot tips, SDH had low activity at the beginning and end of the season when vegetative growth was slowest and a 2:1 sorbitol : sucrose ratio was present. Mid-growing season was, on the other hand, characterized by an increase in SDH activity and a 1:1 sorbitol : sucrose ratio. In 'Nemaguard' seedlings, only SDH activity showed a positive correlation with shoot growth. Also, in root tips of 'Nemaguard' seedlings SDH exhibited its highest activity, even higher than AI activity in the same roots. We concluded that in peach sucrose may represent the major carbon form used for fruit growth, while sorbitol seems to play a predominant role in vegetative growth.

541

Soil Organisms Influence Fine Root Lifespan in Peach

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Damage to the root system by soil insects and pathogenic fungi is difficult to assess and often goes unnoticed until a tree exhibits significant decline above ground. In this study, below-ground imaging technology was used to quantify fine root turnover in peach and to determine what percentage of root death may be caused by soil pests in an apparently healthy orchard. The study was conducted on six 15-year-old 'Loring' peach trees on Halford rootstock in Kearneysville, W.Va. Five root observation tubes were placed in the soil beneath each tree in Apr. 1996. Each tube was randomly assigned one of five soil drench treatments: Lorsban 4E insecticide, Ridomil 2E fungicide, a combination of both pesticides, 1/10th strength Hoagland's solution, or water. A portable VCR and camera system were used to record images of fine roots (<1 mm diameter) growing along the tubes at biweekly intervals from May 1996 through Nov. 1997. The images were used to construct a database of life history information for more than 1500 individual roots. Peach root survivorship was influenced by root diameter and pesticide treatment. Fine roots on tubes receiving either of the pesticide treatments had higher survivorship than roots on control tubes for all diameter classes. The effect was most pronounced for white roots <0.5 mm in diameter, whose survivorship during the growing season was increased by 45% when both insecticide and fungicide were applied. These results suggest that a substantial fraction of fine root death may be caused by interactions with the soil fauna.

542

Winter Bud Cold-hardiness of Interstem Peach Trees

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Large fluctuations in annual peach production is a chronic problem in the southeastern United States. Winter and spring cold injury to flowers reduces the potential peach crop almost every year in the Southeast. A bloom delaying peach interstem has consistently delayed phenology in the Southeast, but its effect on bud hardiness is unknown. Nine varieties (650–1050 chill hours) budded to 'Ta Tao 5' (P.I. 101667) interstems on Lovell rootstock or budded to only Lovell rootstock (i.e., controls) were sampled monthly from November or December to late February in 1996–97 and 1997–98 from an interstem test established in 1993 near Clemson, S.C. High-chill varieties such as 'Contender', 'Encore', and 'Redhaven' were 1 to 2 °C more cold-hardy on interstem trees in late winter. General trends showed that varieties were slightly more cold-hardy on interstems in 1996–97, but no differences were observed from Nov. 1997 through early Jan. 1998. Significant varietal differences in cold-hardiness were found on each sampling date, but no trends were observed.

543

Leaf Gas Exchange and Growth Responses of Young, Container-grown *Annona* Trees to Flooding

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Commercial *Annona* species such as sugar apple and atemoya, are sensitive to flooding. *Annona glabra* (pond apple) is a non-commercial species that grows well

in flooded soils and may have potential as a flood-tolerant rootstock for commercial *Annonas*. The effects of flooding on net CO₂ assimilation (A), stomatal conductance (gs), and vegetative growth of 2-year-old, container-grown *Annona* trees were studied under glasshouse conditions. Seedlings of *A. glabra*, *A. muricata*, and *A. squamosa*, and plants of '49-11' [a cross between atemoya (*Annona* spp. hybrid cv. Gefner) x *A. reticulata*] grafted onto *A. glabra* or *A. reticulata* rootstock ('49-11'/*A. glabra*; '49-11'/*A. reticulata*) were exposed to 50 days of continuous flooding. Non-flooded (control) plants were irrigated daily. Flooded soil became anaerobic from day 3 of initiating the flooding treatment. Seedlings of *A. glabra* and *A. muricata*, and trees of '49-11'/*A. glabra*, produced more vegetative growth during flooding than *A. squamosa* and '49-11'/*A. reticulata*. Flooding decreased A and gs of *A. squamosa* and '49-11'/*A. reticulata*, and caused tree mortality (80%) of *A. squamosa*. Morphological adaptations of *A. glabra* (seedlings and rootstock) to flooding included adventitious root formation into flood water, development of hypertrophied (swollen) lenticels on trunk and adventitious roots, and development of trunk aerenchyma. All seedling trees of *A. glabra* and *A. muricata*, and all grafted trees of '49-11'/*A. glabra* survived 120 days of continuous flooding. *A. glabra* rootstock imparted flood tolerance to the '49-11' scion and may therefore impart flood tolerance to other *Annona* species. *A. muricata* seedlings may withstand extended periods of waterlogging under field conditions.

132 ORAL SESSION 32 (Abstr. 544–551) Vegetable Crops—Crop Physiology

544

Effect of Volatile Reduction on Growth and Development in Closed Atmospheric Chambers

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Plants produce and respond to a broad spectrum of volatile chemical compounds. The concentration and duration of volatile exposure during long-duration space missions will be higher than typically experienced by plants. The effects of using filters to reduce volatile organic compound (VOC) exposure on growth and development of several species has been studied in the Biomass Production Chamber (BPC) at Kennedy Space Center. The VOC composition of the BPC was determined weekly using a modification of EPA Method TO-14 with mass spectrometry. Ethylene concentration was monitored every 8 h using FID gas chromatography. Experiment durations were 84 days for wheat, 105 days for potato, 104 days for rice, and 90 days for tomato. In all cases, non-biological sources including siloxanes, Freon's, solvents and hydrocarbons were the primary VOC constituents. The primary biogenic compounds detected include ethylene, acetaldehyde, pinene, isoprene, and carbon disulfide. Species-specific compounds detected included various terpenes, esters, furans, alcohols, aldehydes, and ethers. Filtering the atmosphere through activated carbon filters typically reduced the overall VOC concentration by at least 50%. Filtering the atmosphere through potassium permanganate pellets generally maintained ethylene concentrations <25 ppb. Concentration difference between filtered and unfiltered treatments varied according to species, stage of development and specific compound. By reducing the overall VOC exposure, several species-specific morphological and development changes were observed, including: an increase in internode length of wheat, potato and rice, delayed anthesis of wheat and tomato, delayed tuber initiation in potato, delayed ripening of tomato, earlier anthesis of rice, and larger leaf area in potato. No phytotoxicity per se was noted during these experiments.

545

Low-level Irradiance during the Dark Period Prevents Photo-periodic-induced Tuberization of Potato

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The threshold irradiance during the dark portion of a photoperiod required to inhibit tuberization of potato (*Solanum tuberosum* L.) was investigated. Two cultivars of potato (cv. Norland, an early maturing variety; cv. Russett Burbank, a late-maturing variety) were grown using nutrient film technique hydroponics in separate tests within a walk-in growth chamber under a normally tuber-inductive

photoperiod (12-h light/12-h dark). Light period photosynthetic photon flux (PPF) was provided by either daylight fluorescent lamps (providing 150 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPF) or a combination of daylight fluorescent and metal halide lamps (providing 300 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPF). The chamber was configured with vertically hung shade cloth and a pair of 15-W cool-white fluorescent lamps mounted at one end of the chamber to provide a range of low irradiance during the dark period. The low irradiance treatments averaged 3.65, 0.43, 0.06, and <0.01 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPF for the entire 12-h "dark" period. Results showed that tuberization occurred around 23 DAP, regardless of cultivar or light period PPF for plants grown with 0.06 and <0.01 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPF during the dark period. Tuberization also occurred at around 30 DAP for cv. Norland grown with 0.43 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPF during the dark period. No tubers were formed for either cultivar grown with 3.65 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPF during the dark period. These results indicate that light levels <0.43 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PPF do not influence photoperiodic induction of tuberization in potato.

546

Does Ethanol-induced Chilling Tolerance Affect the Antioxidant Systems of Cucumber Seedling Roots?

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Previous experiments have shown that chilling-stressed cucumber seedlings treated with ethanol have greater chilling tolerance when compared to untreated seedlings. This chilling tolerance persists for a limited time (2-4 h) and, once lost, chilling tolerance can be re-induced by a second ethanol treatment. In all cases, greater chilling tolerance was measured as an increase in root growth and a decrease in lipid peroxidation and electrolyte leakage. This study was undertaken to determine whether antioxidant systems, which may help plants survive some environmental stresses, are affected by ethanol and/or chilling treatments. The relative activities of glutathione reductase (GR) and peroxidase (POX) of chilled and/or ethanol-treated seedlings were compared. GR activity was suppressed by the combination of any ethanol treatment and chilling when compared to the control. Upon re-warming, all ethanol treated groups exhibited higher GR activity than before chilling. POX activity was affected by the chill plus re-warming treatment in which a significant increase was seen in all treatment groups. Any group treated with ethanol had a lower POX activity than the control. POX activity stains, using non-denaturing PAGE, showed the appearance of three new bands in all treatment groups after the chill and re-warming. The increased intensity of the stain in the re-warmed groups supports the enzyme activity data mentioned above. Since ethanol treatment generally suppressed the enzyme activity after chilling, ethanol's possible role as a scavenger of reactive oxygen species will be discussed.

547

Calcium Uptake and Whole-plant Water Use Influence Pod Calcium Concentration in Green Bean Plants

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Understanding the mechanisms that regulate xylem transport of calcium (Ca) to green bean pods could allow approaches to increase pod Ca concentrations and enhance the nutritional value of edible pods. Using the green bean cultivars 'Hystyle' and 'Labrador', that exhibit high and low pod Ca levels respectively, we wished to determine whether observed differences in Ca concentration of stem xylem-sap were related to differences in whole-plant water uptake and Ca import. Well-watered greenhouse-grown plants, selected at flowering and at two stages of pod development, were placed in a growth chamber at a constant light intensity. Pot weight loss was measured to determine whole-plant water use and stem xylem exudate was subsequently collected from the severed base of the shoot. 'Hystyle' displayed 50% higher Ca concentration in exudate than 'Labrador' during pod development. Labrador showed 35% greater total water transport through the stem than 'Hystyle'. Additional plants were used to determine total, long-term Ca uptake. No significant differences in total Ca were seen between cultivars at the three harvest dates. With whole-plant Ca uptake being equivalent, the results suggest that higher water uptake in 'Labrador' led to a dilution of Ca in the xylem stream and thus less total Ca was transported to developing pods, relative to that in 'Hystyle'. These results reveal that green bean varieties with low whole-plant water use have the potential to yield edible pods with elevated Ca content.

Endo- β -mannanase Activity and Seed Germination of Thermosensitive Lettuce Genotype in Response to Temperature and Seed Priming

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Under high temperatures (above 30 °C) in the greenhouse (transplant industry) or field, lettuce germination can be erratic or completely inhibited. Seed priming circumvents thermodormancy of lettuce seeds and allows germination at higher temperatures. Weakening of the endosperm layer of lettuce seeds is a prerequisite to radicle protrusion at high temperatures. Enzyme-mediated degradation of endosperm cell walls may be a crucial factor for lettuce seed germination at high temperatures. Softening of the endosperm could occur during seed priming and result in improved germination. A single-seed assay for endo- β -mannanase was used to follow the activity of this enzyme during priming in lettuce seeds. We also investigated the effects of seed priming on seed germination and mannanase activity at both inhibitory and non-inhibitory temperatures for seed germination in a thermosensitive lettuce cultivar Dark Green Boston. Seeds were primed for 3 days at 15 °C with constant light in aerated solutions of polyethylene glycol (PEG) at an osmotic potential of -1.2 MPa. Afterward, seeds were rinsed and redried at 10 °C and 45% RH for 3 days. Primed and nonprimed seeds germinated 100% at 20 °C. At 35 °C, primed seeds germinated 100%, whereas nonprimed seeds did not germinate. During priming, endo- β -mannanase activity increased between 24 and 72 h after the beginning of osmotic imbibition. Mannanase activity persisted in primed seeds, even following seed drying. Radicle protrusion did not occur under the priming conditions used in this study. Higher enzyme activity was observed in primed seeds compared with nonprimed seeds. The results suggest that priming overcomes the inhibitory effect of high temperature in thermosensitive lettuce seeds by weakening of endosperm due to increased endo- β -mannanase activity.

549

Low-temperature Storage of Micropropagated Broccoli Plantlets under Varying Light Quality

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Micropropagation is often associated with mass production at a competitive price. Since labor accounts for a large portion of micropropagation costs, alternative measures to distribute labor costs are necessary. One such method of distributing labor costs is the use of storage systems to hold micropropagated plantlets until market availability. Broccoli (*Brassica oleracea* L. 'Green Duke') plantlets were cultured photoautotrophically (without sugar) or photomixotrophically (with sugar) on cellulose plugs in liquid media in vitro for 3 weeks at 23 °C and 150 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ photosynthetic photon flux (PPF). To determine the conditions that yield a zero carbon balance, plantlets were subsequently stored for 3 d under different temperatures (1, 5, 10, 15 °C), different light intensities (1.6, 4.1, 8.6 PPF), and different light spectra (provided by white or blue fluorescent bulbs or red Light Emitting Diodes). Plantlets under 3 PPF and 1 °C maintained a zero carbon balance. Subsequently, plantlets were stored for 4, 8, or 12 weeks at 1 °C under darkness or 3 PPF of white, red, or blue light. Prior to low temperature storage, photomixotrophic plantlets were characterized by increased chlorophyll, dry mass, total soluble sugars (TSS), leaf starch, and net photosynthetic rate (NPR). Illumination during storage was necessary to maintain dry mass, TSS, NPR, and regrowth potential of photoautotrophic plantlets. When sucrose was provided to the media, dark stored plantlets survived up to 12 weeks of storage. During storage, the quality of broccoli plantlets was best maintained under red light. Red light increased chlorophyll, TSS, and dry matter accumulation into leaves during storage. In addition, photoautotrophic plantlets stored for 8 or 12 weeks under red light had higher survival rates once acclimatized to the greenhouse when compared to photoautotrophic plantlets stored in darkness or under white or blue light.

550

Reproductive Responses of *Capsicum annuum* to High Temperatures

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Fruit yield reduction due to high temperatures has been widely observed in Solanaceous crops. Our past experiments have demonstrated that *Capsicum annuum* cultivars Ace and Bell Boy completely fail to produce fruit when grown at constant 33 °C. However, flowers are produced, continually. To determine which stages of flower development are sensitive to high temperatures, pepper buds, ranging in size from 1 mm to anthesis, were exposed to high temperatures for 6 hr, 48 hr, 5 days, or for the duration of the experiment. Fruit set for each bud size was determined. Exposure to high temperatures at anthesis and at the 2-mm size stage for 2 or more days significantly reduced fruit production. To determine whether inhibition of pollination, inhibition of fertilization, and/or injury to the female or male structures prevents fruit production at high temperatures, flowers from pepper cultivars Ace and Bell Boy were grown until flowers on the 8th or 9th node were 11 mm in length. Plants were divided between 25 °C and 33 °C constant growth chambers for 2 to 4 days until anthesis. At anthesis, flowers from both treatments were cross-pollinated in all combination, and crosses were equally divided between 33 or 25 °C growth chambers until fruit set or flowers abscised. All flower crosses resulted in 80% to 100% fruit set when post-pollination temperatures were 25 °C. However, post-pollination temperatures of 33 °C significantly reduced fruit production. Reduced fruit set by flowers exposed to high temperatures during anthesis and pollination is not a result of inviable pollen or ovule, but an inhibition of fertilization or initial fruit development.

551

Flower Development and Yield of *Cucurbita* in Four Locations Differing in Temperature

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Preliminary greenhouse experiments indicated that *Cucurbita pepo*, when grown at high temperatures, shows a high incidence of female flower bud necrosis, preventing those flowers from reaching anthesis and thus delaying fruit set. This can lead to reduced yield in areas with short growing seasons. To determine if delayed fruit set also occurred under field conditions, replicated cultivar trials were conducted during the summer seasons of 1996 and 1997 in Ithaca and Albany, N.Y.; Wye, Md., and Bradenton, Fla. Mean growing season air temperatures were 20, 21, 24, and 28 °C, respectively, at the four locations. Delay in fruit set was indicated by the main stem node number at which the first fruit formed. In Ithaca and Albany, the six cultivars grown in both years formed their first fruit at node 17, while this was shifted to node 24 at Wye, and to node 26 or more at Bradenton. Fruit yields among the *C. pepo* cultivars ranged from 45 to 85 $\text{mt}\cdot\text{ha}^{-1}$ in all locations except Bradenton, where they ranged from 7 to 35 tons. Among *C. pepo* cultivars, 'Appalachian' showed least yield decrease at Bradenton, and 'Howden' and 'Baby Bear' the most, in the hotter 1996 season. The *C. maxima* 'Prize Winner' yielded well in all locations. The results indicate that delayed fruit set occurred most often in the highest temperature locations. There is scope for selecting for improved high temperature female flower development among *C. pepo* cultivars.

133 ORAL SESSION 33 (Abstr. 552–559)

Vegetable Crops—Postharvest Physiology & Food Science

552

Distribution of Glucosinolates and Myrosinase Activity in Cruciferous Vegetables

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A diet rich in cruciferous vegetables has been associated with inhibition of chemically induced carcinogenesis in laboratory animals and humans. The underlying mechanism(s) for this inhibition is not completely clear; however, cruciferous vegetables are rich in sulfur-containing glucosides called gluco-

sinolates. Myrosinase-mediated breakdown of glucosinolates has been shown to produce compounds with anti-cancer activity. About 100 forms of glucosinolates have been identified, mostly in the *Cruciferae* family. In this study, we have developed a unique data set of glucosinolate types and amounts in 51 broccoli, three cauliflower, five Brussels sprouts, five cabbage, and two kale lines. The types of glucosinolates and their concentrations were variable among the different genotypes and within each genotype. The dominant glucosinolates in broccoli were glucoraphanin, gluconapin, and glucobrassicin. Glucoraphanin concentration in broccoli ranged from 0.1 $\mu\text{mol}\cdot\text{g}^{-1}$ dry weight in EV6-1 to 21.7 $\mu\text{mol}\cdot\text{g}^{-1}$ dry weight in Brigadier. Concentrations of the other types of glucosinolates in broccoli also showed wide range of variability. In cabbage, Brussels sprouts, cauliflower, and kale, the dominant glucosinolates were sinigrin (7.8, 8.9, 9.3, and 10.3 $\mu\text{mol}\cdot\text{g}^{-1}$ dry weight, respectively) and glucobrassicin (0.9, 3.2, 1.3, and 1.2 $\mu\text{mol}\cdot\text{g}^{-1}$ dry weight, respectively). Brussels sprouts also has significant amounts of gluconapin (6.8 $\mu\text{mol}\cdot\text{g}^{-1}$ dry weight). Myrosinase activity, using sinigrin as substrate, was significantly higher in cabbage, Brussels sprouts, cauliflower, and kale than in broccoli. Wide variations in glucosinolates, glucosinolates content, and myrosinase activity among cruciferous genotypes and within each genotype suggest differences in the health-promoting properties of these vegetables.

553

Thermal Blast Peeling of Sweetpotatoes

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Thermal blast peeling is a process whereby peels and blemishes are efficiently removed from produce by holding the produce for a brief period in a heated, closed vessel filled with superheated steam under elevated pressure while supplemental radiant heat is supplied by the vessel wall. This intense, dry heat superheats a film of moisture immediately underlying the peel tissue. The pressure within the vessel is then instantaneously reduced by opening the vessel. Steam within the vessel expands blowing the produce free of the vessel and simultaneously the superheated water in and immediately underlying the peel flashes to steam thus cleanly exploding the peel tissues from the produce. Different size grades and cultivars of sweetpotatoes were peeled by the Thermal blast process, hot caustic immersion, or by high-pressure saturated steam. Thermal blast-peeled sweetpotatoes had higher product recoveries, less heat penetration into the tissue, and better color than caustic or saturated steam-peeled potatoes.

554

Thermal Blast Peeling of Peppers

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The skins of peppers are tightly attached to the flesh and do not readily separate by moderate scalding or steaming. In commercial canning operations, skin separation is achieved by immersion in hot caustic or by flaming. These treatments remove a substantial portion of edible pod tissue and cause tissue collapse and loss of product quality. Thermal blast peeling is a process whereby peels and blemishes are efficiently removed from produce by holding the produce for a brief period in a heated, closed vessel filled with superheated steam under elevated pressure while supplemental radiant heat is supplied by the vessel wall. This intense, dry heat superheats a film of moisture immediately underlying the peel tissue. The pressure within the vessel is then instantaneously reduced by opening the vessel. Steam within the vessel expands blowing the produce free of the vessel and simultaneously the superheated water in and immediately underlying the peel flashes to steam thus cleanly exploding the peel tissues from the produce. Pimiento peppers and jalapeno peppers were peeled by the Thermal blast process and compared to caustic peeled peppers. Product yields, Instron texture analysis, and color were compared in both the raw peeled fruit and in the canned peeled product. Volatile flavor profiles were analyzed by head space gas chromatography. Thermal blast-peeled peppers had firmer texture, thicker pod walls, and better color than caustic-peeled peppers. Thermal blast-peeled peppers had head space volatiles similar to unheated raw peppers.

555

Nondestructive Quality Evaluation of Tomatoes

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Both external and internal quality of fruits such as tomatoes can be evaluated by different methods, but all most all of the methods are destructive. For this reason, there is a need to reassess some of the alternative techniques. Nondestructive quality evaluation is an attractive alternative. The principles of different nondestructive quality evaluation techniques such as optical, physical, and fluorescence techniques applied to tomato fruit is explained. Successful application of these techniques that could be used for evaluation of different quality attributes are illustrated. The advantages of nondestructive quality evaluation techniques are that they are very fast, easy, labor- and time-intensive, and inexpensive. These techniques could also be useful to evaluate the quality of other vegetables.

556

Apoplastic pH and Mineral Composition during Ripening of Tomato Pericarp

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Ionic conditions and pH affect the catalytic activity of polygalacturonase and other cell wall enzymes, as well as non-enzymic pectin solubilization. Despite its potential role in regulating fruit ripening, apoplastic pH and mineral composition in ripening fruit are poorly documented. A pressure-extracted fluid was obtained from tomato pericarp, using a constant pressure of 0.6–0.7 MPa for immature and mature-green fruit and 0.3–0.5 MPa for pink and red fruit. The osmolality of the pressure-extracted fluid ranged from 66 to 138 $\text{mmol}\cdot\text{kg}^{-1}$ compared with 268 to 293 $\text{mmol}\cdot\text{kg}^{-1}$ for the bulk pericarp homogenate, which attests to the putative apoplastic origin of the fluid. The pH of the apoplastic fluid was 6.7 at the immature and mature-green stages and dropped to 4.4 by the ripe stage, whereas bulk pericarp pH dropped from 4.6 to 4.3. $[\text{K}^+]$ in the apoplast increased from 13.2 mM at the mature-green stage to 37.3 mM at the ripe stage, whereas the bulk tissue $[\text{K}^+]$ ranged from 44 to 49 mM without relation with ripening stage. $[\text{Mg}^{2+}]$ declined from 11.9 mM in immature fruit to 8.7 mM in mature-green fruit and then increased to 12.9 mM in ripe fruit. $[\text{P}]$ increased from 1.5 to 4.8 mM during ripening, and $[\text{Cl}^-]$ remained around 3.8 to 4.0 mM until the pink stage, increasing to 6.5 mM at the ripe stage. $[\text{Na}^+]$ remained constant at 6.2 to 6.5 mM, whereas $[\text{Ca}^{2+}]$ ranged from 3.5 to 4.9 with no consistent relationship with ripening stage. The changes in pH and ionic composition of the pericarp apoplast may affect the binding and catalysis of cell wall hydrolases and physical interactions between structural polysaccharides.

557

Sugar Changes, Respiration, and Decay Control of Sweetpotatoes in Consumer Packages

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Cured 'Beauregard' sweetpotatoes [*Ipomoea batatas* (L.) Lam] were either treated with a fungicide (300 ppm, 2,6-dichloro-4-nitroaniline), hot water (55 °C for 5 min), a combination of the two treatments, or untreated. The roots were shrink-wrapped in 2.3-kg consumer packs using a Clysar D 955 heat-shrinkable film. The packs were kept at room temperature, which ranged from 18 to 22°C, for 4 weeks. The average CO₂ concentration in the packages was 18% after the 4-week period. Roots in the wrapped packages lost 0.7% fresh weight, whereas nonwrapped roots lost 4.2% fresh weight. Shrink-wrapped roots maintained a lower rate of respiration for several days after removal from the packages. Hot water and fungicide treatments reduced *Rhizopus spp.* decay and enhanced root appearance. An additional benefit of hot water treatment was an inhibition of sprouting. Wrapped sweetpotatoes had lower alcohol insoluble solids and dry weight. The concentration of fructose and glucose was higher in wrapped roots, while sucrose concentration was lower. There was also a 20% increase in both acid and neutral invertase activity in the wrapped roots compared to nonwrapped roots. Hot water treatment is a viable alternative to fungicides in extending shelf-life of consumer packaged sweetpotatoes.

558

Postharvest Application of Calcium to Whole Muskmelon Fruits

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Fully mature, abscised, hybrid netted- and honey dew-muskmelon fruits submerged in amino acid-calcium (AA-Ca) chelate solutions, vs. non-calcium treated fruits, were less senescent and had little or no surface decay following 21 days at 10 °C (honey dew) or 4C (netted) plus 3 days at 21 °C. Honey dew fruits submerged in either AA-Ca or AA-Ca plus AA-Mg, and netted fruits in AA-Ca plus AA-Mg, had hypodermal-mesocarp tissue $[Ca^{2+}]$ of 6.0 mg per g dry mass or higher 10 days postharvest, which is statistically similar to $[Ca^{2+}]$ in freshly harvested fruits. Non-calcium treated vs. calcium treated fruits, 10 days postharvest, had significantly less 6.0 mg per g dry mass $[Ca^{2+}]$. Maintaining muskmelon hypodermal-mesocarp tissue $[Ca^{2+}]$ at 6.0 mg per g dry mass or higher maintained membrane integrity as evidenced by low free sterol: total phospholipid ratio (mol:mol), low electrolyte leakage, high total and specific H^+ -ATPase activities, and low lipoxygenase activity; maintained fruit firmness; and extended fruit storage life 2.4-fold (i.e., to 24 days) vs. non-calcium treated fruits. Application of calcium to abscised, fully ripe honey dew and netted muskmelon fruits should reduce fruit senescence rate in storage and should promote extended market-life and a higher quality product.

559

Making Sense of Cooling Data

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Prompt cooling to remove field heat is an essential part of proper postharvest handling for many types of fresh fruits and vegetables. Growers, consultants, and horticultural agents are often encouraged to collect cooling data (time vs. temperature) in order to compare cooling rates for different systems, containers, etc. These data can be misleading and confusing and seldom yield much useful information. With proper analysis, cooling data can yield a large amount of information. The problem is not the fault of the data, as much as the lack of simple methods to analyze these data. This presentation will demonstrate several simple methods to extract useful information from cooling data.

134 ORAL SESSION 34 (Abstr. 560–567) Vegetable Crops—Culture & Management

560

Potassium Fertilization Affects Yield and Leaf Mineral Concentration of Slicing Cucumber

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Successful fertilization of a crop depends on knowing the crop nutrient requirement (CNR) for production of maximum economic yield and on using soil tests that are properly calibrated and correlated with crop response. During Summer 1997, 'Lightning' cucumber was grown with white-on-black polyethylene mulch, methyl bromide fumigation, and drip irrigation on beds with 1.2-m centers. Two rows of cucumbers were planted per bed with an in-row spacing of 30.5 cm. Treatments were 0, 40, 85, 170, 340 $kg \cdot ha^{-1}$ K on a soil testing "low" in potassium (Mehlich 1 extractable K = 24.3 $mg \cdot kg^{-1}$ soil). Treatments were applied 20% preplant and the remainder injected through drip irrigation in five equal amounts as determined by treatment. The most recently matured leaf was sampled at first flower, full bloom, and first harvest for determination of K concentration. Leaf K concentration at first flower showed a quadratic response with a maximum of 54 $g \cdot kg^{-1}$ at 445 $kg \cdot ha^{-1}$ K. At full bloom and first harvest sampling, leaf K concentration showed a linear response over the range of 0 to 340 $kg \cdot ha^{-1}$ K. Leaf K was deficient for plants receiving 0 and 40 $kg \cdot ha^{-1}$ K at the full bloom sampling. Early yields (harvests 1+2) of U.S. number 1 and total marketable fruits increased linearly over the treatment range. Season total yield of U.S. fancy and total marketable fruits increased quadratically with maxima of 43 $MT \cdot ha^{-1}$ and 67 $MT \cdot ha^{-1}$ at K rates of 270 $kg \cdot ha^{-1}$ and 300 $kg \cdot ha^{-1}$, respectively, while U.S. number 1 yield increased linearly.

561

Effect of Plant Population on Muskmelon Yield and Quality

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Muskmelon plant populations and arrangements were evaluated at two sites in North Carolina in 1997. Within-row plant spacings of single rows were 0.15, 0.30, 0.46, 0.61, and 0.76 m, while staggered twin row spacings were 0.30, 0.46, and 0.61 m. The trials were conducted on black plastic with drip irrigation at both locations using the 'Athena' cultivar. One trial was seeded 22 Apr., the other was transplanted 21 May. Yield was recorded as fruit number and weight. Soluble solids measurements were also taken. Yields were nearly two times greater when planted on 22 Apr. than 21 May. Yields in the later planting ranged between 13,300 and 18,800 melons per hectare, while yields in the earlier planting ranged between 23,700 and 31,600 melons per hectare. Populations arranged in staggered twin rows on the bed provided no yield advantage compared with single rows. As in-row plant spacing increased, yields of large-sized fruit (>2.0 kg) tended to be greater, while production of smaller size marketable fruit (1.4 to 2.0 kg) tended to be greater as in-row plant spacing decreased. Soluble solids were not affected by plant population.

562

Drip Irrigation and Stand Establishment Affect Yield and Quality of Cantaloupe

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Water pumping restrictions of high-quality irrigation water from underground aquifers is affecting vegetable production in Southwest Texas. There is a need to develop efficient deficit-irrigation strategies to minimize irrigation inputs and maintain crop profitability. Our objective was to determine how growth, yield, and quality of cantaloupe (*Cucumis melo* L. cv. 'Caravelle') are affected by irrigation systems with varying input levels, including drip depth position and polyethylene mulch. Stand establishment systems used were containerized transplants and direct seeding. Field experiments were conducted on a Uvalde silty clay loam soil. Marketable yields increased in the order of pre-irrigation followed by: dry-land conditions, furrow/no-mulch, furrow/mulch, drip-surface (0 cm depth)/mulch, drip-subsurface (10-cm depth)/mulch, and drip-subsurface (30 cm depth)/mulch. Pooled across all drip depth treatments, plants on drip had higher water use efficiency than plants on furrow/no-mulch or furrow/mulch systems. Transplants with drip-surface produced 75% higher total and fruit size No. 9 yields than drip-subsurface (10- or 30-cm depth) during the first harvest, but total yields were unaffected by drip tape position. About similar trends were measured in a subsequent study except for a significant irrigation system (stand establishment interaction) for yield. Total yields were highest for transplants on drip-subsurface (10-cm depth) and direct seeded plants on drip-subsurface (10 and 30 cm depth) with mulch.

563

Winter Production of 'Galia' Muskmelons in Northern Florida Using Protective Structures and Soilless Culture

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Vegetable production in southern Florida is being displaced northward due to escalating land prices. In order to produce vegetable crops in northern Florida during the cooler months when southern Florida has traditionally captured the winter market, methods of protecting crops from the cold must be investigated. In addition, the impending ban of methyl bromide in 2001 under the Clean Air Act mandates research on alternative crop production methods not requiring this soil fumigant. We grew 'Galia' muskmelons [*Cucumis melo* var. *reticulatus* (L.)] under walk-in tunnels and low-tunnels (rowcovers) during the Winter/Spring of 1997 and the Fall/Winter/Spring of 1997–1998. The walk-in tunnels were quonset style structures, 10 by 20 m, covered with a single layer of polyethylene film. Three of the six walk-in tunnels had a passive heating system consisting of four water tubes each 30.5 cm in diameter and 15.25 m long, which absorbed solar energy and released it as thermal energy during cool nights. Half of all melons in each tunnel treatment were grown hydroponically in bags of perlite; the other half were grown in mulched, raised soil beds. In Spring 1997 experiment, early yield, total marketable yield, soluble solids concentration, and average fruit weight were greater with passively heated and unheated walk-in tunnels than with low-tunnels. Total marketable yield and average fruit mass were greater for melons grown in soil than for melons grown in perlite. Soluble solids concentrations were similar

for melons grown in soil and perlite.

564

Plant Population, Seedlings per Hill, Cultivar, and Plastic Mulch Affect Watermelon Yield, Size, and Quality

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Plant population, seedlings per hill, cultivar and plastic mulch were evaluated in five environments for their affect on watermelon yield, size and quality. 'Royal Jubilee' outyielded 'Prince Charles' in all environments, and the highest yields were associated with low % culls and high fruit numbers per hectare. Highest yields of marketable fruits (>4.5 kg/melon) were obtained using mulch and areas per plant between 0.4–0.9/m. Unless there is a market for small fruits (<4.5 kg), optimum area per plant was 1 m²/plant. Results for one plant/hill at one in-row spacing were similar to those for the alternative planting pattern of two plants/hill at half the in-row spacing, thus supporting the feasibility of using the more economical alternative planting pattern.

565

Foliar and Spatial Requirements for Watermelon

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Unrestricted watermelon plants will cover large areas of soil surface, and watermelons are normally planted in rows 2 to 3 m apart to allow vine extension. Even so, machinery used for cultivating, spraying, and harvesting may crush vines, thereby reducing plant size and restricting the ground surface area available to the plant. Insect or disease defoliation may limit the leaf surface area that is available for fruit production. Some farmers intentionally limit vine length or surface area in the belief that this will promote fruit set. Experiments with *Citrullus lanatus* (cv. Sangria, Crimson Trio, and Scarlet Trio) have been conducted in southeastern Oklahoma to determine the effect of branch number, branch length, melon number, and root volume on fruit yield. Branch length was limited to 1.2, 2.4, 3.7, or 4.9 m, and branch number was limited to either one or two branches per plant. An unpruned control treatment was included for comparison. Limitation of branch length limited fruit yield. Likewise, limitation of branch number limited fruit yield. Watermelons were also grown in a series of 10 containers that ranged in volume from 0.1 to 1.0 m³. Root volume was directly correlated with watermelon yield, but the effect was minimal. Marketable melons were produced in containers as small as 0.1 m³ volume.

566

Germination Response of 'Genesis' Triploid Watermelon [*Citrullus lantau* (Thunb.) Matsum & Nakai] to Hydrogen Peroxide and Seed Coat Alteration

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Triploid watermelons are fast becoming a highly desirable specialty crop. Poor germination and nonuniform emergence of the relatively expensive seed prohibits to many potential growers. Improvement of germination and emergence of triploid watermelons would reduce overall risk to a grower, thus increasing the crops market prominence. Seeds of 'Genesis' triploid watermelon were subjected to three treatments: 1) seed coat removal; 2) clipping the seed coat opposite the radicle end, and 3) no seed coat alteration. Seeds from each treatment were germinated on agar alone or in the presence of 5 ml of a 1%, 2%, 4%, or 8% solution of H₂O₂. Test were conducted in a constant temperature (28 °C) growth chamber in the dark. Seed coat removal, clipping, and all levels of H₂O₂ increased final germination percentages relative to the control. Germination differences as great as 70% occurred. Hydrogen peroxide levels greater than 2% resulted in severe injury to germinating seeds.

567

Influence of Cyclic Cold Temperature Stress on Watermelon Seedling Growth, Earliness, Yield, and Quality

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Watermelon seedlings may be repeatedly exposed to temperatures alternat-

ing between almost freezing and optimal temperatures for growth during stand establishment in coastal South Carolina. 'Carnival' watermelon transplants were exposed to 2 °C for 3, 6, and 9 h, for 1, 3, 6, and 9 days in a walk-in cooler and then to warm temperatures (24 °C) immediately prior to field planting. Our objective was to determine the long term effect of early season cold temperature exposure on seedling growth, earliness, yield and quality by simulating the cold/warm alternations possible in the field. Cold-stressed transplants were field planted after the risk of ambient cold stress was negligible. Exposure to cycling cold temperatures generally did not affect earliness, total productivity and quality, although seedling growth characteristics were reduced in response to the longer cold-stress treatment. Therefore, cold temperature stresses occurring in the field at transplanting have negligible beneficial or detrimental effects on yield potential of 'Carnival' watermelon.

139 ORAL SESSION 35 (Abstr. 568–572) Vegetable Crops—Breeding & Genetics

568

Genetic Similarity Among Broccoli Inbreds "Essentially Derived" from Commercial Cultivars

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DNA markers can assess close genetic relationships between individuals of a crop as when one variety is developed (i.e., "essentially derived") from another. An acceptable threshold, based on empirical results, should be established for a crop to indicate what constitutes an "essentially derived" variety in the absence of clear pedigree information. Empirical data could help settle infringements of intellectual property rights, but appropriate data are not being generated for most crops. Thus, our objectives were to characterize genetic relationships among broccoli varieties "essentially derived" from known parents using random amplified polymorphic DNA (RAPD) markers as a measure of genotype and to provide an empirical basis for threshold levels in this crop. Six F₁ broccoli hybrids and three inbred lines (doubled-haploids) developed from each of the hybrids (24 entries) were evaluated by RAPD analysis. RAPD assays were conducted using 23 different oligonucleotide 10-mers. Of 179 RAPD bands scored, 94 were polymorphic among the entries. Similarity indices were computed from RAPD data, and a multi-dimensional scaling (MDS) plot was constructed. Similarity indices for all pairwise comparisons ranged from 0.40 to 0.90. 'High Sierra' and its derived lines were the most closely related group with indices from 0.81 to 0.90. With 'High Sierra', 'Sultan', and 'Marathon', the three derived lines were more closely related to their respective parental hybrids than were any other entries. The hybrids 'Futura', 'Everest', and 'Viking' were more genetically similar to other entries than to their derived lines. A threshold level based on data from 'High Sierra', 'Marathon', 'Sultan', and their derived lines would not identify "essentially derived" lines developed from other hybrids.

569

Molecular Marker Linked to High Solanine/Chaconin (Nil/Low Leptin) in *Solanum chacoense*, and Implications for Leptine Biosynthesis

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Solanum chacoense, a wild relative of the cultivated potato, contains several glycoalkaloids, including solanine, chaconine, and leptine. The foliar-specific leptine glycoalkaloids are believed to confer resistance to the Colorado Potato Beetle (CPB). Data from segregating F₁ populations developed from crosses of high x nil and high x high leptine producers were consistent with control of leptine production by a single recessive gene; however, data from subsequent generations strongly suggests the presence of additional factors affecting the inheritance and expression of leptine glycoalkaloids in this population of *S. chacoense*. Using two bulked DNA samples composed of high- and low-percent leptine individuals from a segregating F₁ population of *S. chacoense*, a 1500-bp RAPD product, UBC370-1500, was identified that is closely linked to high percent solanine+chaconine, and

conversely to low percent leptine. This marker mapped to the end of the short arm of potato chromosome 1, near the location of a previously mapped major QTL for solanidine. The observed distribution of the UBC370-1500 marker, in conjunction with these QTL data, suggest that hydroxylation of a common precursor to form leptinidine occurs prior to formation of the solanidine aglycone. Implications of these findings for the development of CPB-resistant potato varieties will be discussed.

570

Comparative Mapping of Three Bacterial, Three Fungal, and One Virus Disease-resistance Genes in Common Bean

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Common bacterial blight (CBB), bacterial brown spot (BBS), and halo blight (HB), incited by the bacterial pathogens *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye, *Pseudomonas syringae* pv. *syringae*, and *Pseudomonas syringae* pv. *phaseolicola*, respectively are important diseases of common bean. In addition three fungal pathogens, web blight (WB) *Thanatephorus cucumeris*, rust *Uromyces appendiculatus*, and white mold (WM) *Sclerotinia sclerotiorum*, are also destructive diseases attacking common bean. Bean common mosaic virus is also one of most major virus disease. Resistance genes (QTLs and major genes) to three bacterial (CBB, BBS, and HB), three fungal (WB, rust, and WM), and one viral pathogen (BCMV) were previously mapped in two common bean populations (BAC 6 x HT 7719 and Belneb RR-1 x A55). The objective of this research was to use an integrated RAPD map of the two populations to compare the positions and effect of resistance QTL in common bean. Results indicate that two chromosomal regions associated with QTL for CBB resistance mapped in both populations. The same chromosomal regions associated with QTL for disease resistance to different pathogens or same pathogens were detected in the integrated population.

571

Detection and Mapping of RAPD Markers Associated with QTL Affecting Seed Size and Shape in Common Bean

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Seed size is an important trait in common bean. The objective was to identify RAPD markers associated with QTL for seed weight, seed length, and seed height in a molecular marker-based linkage map in a recombinant inbred (RI) population from the common bean cross of the larger seeded (100 seed/39 to 47 g) PC-50 (ovate seed shape) x smaller seeded (100 seed/26 to 35 g) XAN-159 (flat rhomboidal seed shape). The parents and RI lines were grown in two separate greenhouse and two field (Wisconsin, Dominican Republic) experiments using a RCBD. Continuous distributions for seed weight, seed length, and seed height were observed for RI lines indicating quantitative inheritance. One to three QTLs affecting seed weight explained 17% to 41% of the phenotypic variation. Two to three QTLs for seed length explained 23% to 45% of the phenotypic variation. One to four QTL associated with seed height explained 17% to 39% of the phenotypic variation. A RAPD marker M5.850 in linkage group 3 was consistently associated with seed weight, seed length, and seed height in all experiments and explained 7% to 13% of the phenotypic variation for these traits. A seedcoat pattern morphological marker (*C*) in linkage group 1 was associated with seed weight and seed height in two greenhouse experiments.

572

Mapping of Five Morphological Markers (*dgs*, *blu*, *rmd*, *lb*, and *asp*) in a Molecular Linkage Map of Common Bean

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The classical genetic linkage map of common bean contains only a fraction of the total genes that has been reported. These genes can be mapped in a molecular linkage map so that genetic relationship among different genes can be better understood. The objective of this study was to identify RAPD markers linked to genes for five morphological traits using bulked segregant analysis and to map the markers to a molecular linkage map previously constructed in common bean.

Five segregating populations were evaluated. Three BC₃F₂ populations with *dgs* (dark green savoy leaf), *blu* (blue flower), and *rmd* (round leaf), respectively, were developed with a Florida breeding line 7-1404 and 5-593 as the recurrent parent. One BC₃F₂ population with the *asp* (dull seed coat) was developed from a BC₂F₂ 5-593 line and 5-593 as the recurrent parent. Finally, an F₂ segregating population for *lb* (flat pod) was developed from 'Hialeah' flat pod mutant x 'Hialeah'. The linked RAPD markers were mapped in a molecular linkage map previously constructed using recombinant inbred population of the cross PC-50 x XAN-159. The results of this study indicate that integrating morphological and molecular markers can result in a more complete genetic linkage map in common bean.

140 ORAL SESSION 36 (Abstr. 573–578) Fruits/Nuts—Culture & Management

573

Effect of Canopy Angle and Row Spacing on Tree Growth, Yield, Light Interception, and Fruit Quality of Y-trellis-trained Apple Trees

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'Empire'/M.9/MM.106 and 'Ace Delicious'/MM.106 apple trees were planted in 1985 at three between row spacings (3.0 m, 4.25 m and 5.5 m) and were trained as either free standing central leaders or as Y-shaped hedgerows for 13 years. The Y hedgerow arms had varying angles from 40° to 80° above the horizontal. Final scaffold length, canopy volume, trunk cross-sectional area, and above-ground canopy weight were positively correlated to the angle of the Y arms. As the angle of the Y arms became more horizontal, the amount of growth removed during summer pruning increased. At the flattest angle (40° above horizontal), terminal growth of both cultivars ceased and excessive vertical sucker growth resulted. As the angle of the Y arms became more vertical, more terminal growth was obtained and less shoot growth had to be removed during summer pruning. Cumulative yields of the Y-shaped trees were generally greater than those of the central-leader-trained trees. Exceptions were the most horizontal and the most vertical canopy angles, which had the lowest yields. The relationship between angle of Y arms and yield showed a broad optimum between 50° and 70° above the horizontal. There was also a strong positive relationship between tree density and yield. 'Empire' fruit size was smaller from the Y-shaped trees than from the central-leader trees. The optimum angles for fruit size were the intermediate angles. Fruit color was poorest on the flattest angles and best on the most-vertical angles. The best yield efficiency was at intermediate angles (50°-70°). This resulted in the best balance of vegetative growth and cropping.

574

Orchard Groundcover Systems Affect Meadow Vole Populations and Damage to Apple Trees.

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Meadow vole (*Microtus pennsylvanicus* L.) populations, feeding activity, and damage to young apple (*Malus domestica* Borkh.) trees were monitored by direct observation, trap counts, and a feeding activity index in different groundcover management systems (GMSs) for five years in a New York orchard. Vole populations differed greatly among GMSs, with consistently higher populations and more damage to tree trunks in crownvetch (*Coronilla varia* L.), hay-straw mulch, and red fescue (*Festuca rubra* L.) sodgrass GMSs. Vole populations were highest in the fall and lowest during the spring seasons each year. Anticoagulant rodenticides and natural predation did not result in adequate control of voles in GMSs that provided favorable habitat for nesting and feeding of this pest. The percent of soil surface vegetation coverage was not, but the amount of groundcover biomass was, a significant predictor of vole populations and damage to trees, independent of groundcover vegetation species. Trunk applications of thiram fungicide were less effective than 40-cm-high plastic mesh trunk guards, but better than no protective measures for controlling vole depredation in groundcover management systems (GMSs) with high rodent populations. A combination of late fall vole trapouts, close and consistent mowing of orchard floor vegetation, tree trunk protection with mesh guards, ample surrounding habitat for natural predators of voles, and

suppression of tree row groundcover species with herbicides provided adequate control of meadow voles without the use of rodenticides at this orchard.

575

Hydrophobic Particle Films Improve Tree Fruit Productivity

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Hydrophobic particle film technology (HPF) is a developing pest control system for tree fruit production systems. Studies were established in Chile, and Washington, Pennsylvania, and West Virginia in the United States, to evaluate the effect of HPF technology on tree fruit yield and quality. Studies in Chile, Washington, and West Virginia demonstrated increased photosynthetic rate at the leaf level. Yield was increased in peaches (Chile) and apples (West Virginia), and fruit size was increased in apples (Washington and Pennsylvania). Increased red color in apple was demonstrated at all sites with reduced russetting and 'Stayman' cracking in Pennsylvania. HPF technology appears to be an effective tool in reducing water and heat stress in tree fruit resulting in increased fruit quality.

576

Long-term Performance of Asian Pear Trees in Maryland

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Three Asian pear plantings were set during the past decade. Plantings included an initial cultivar planting on OH x F rootstock, the SE Zonal planting, and a rootstock by cultivar factorial. Fireblight susceptibility and survival were assessed in the first two plantings following a summer hailstorm. Trees were compared to Magness, a blight-tolerant buttery pear. Shin Li, Daisu Li, Shinsui, and Olympic were more resistant than Magness, while Chojuro and Niitaka were nearly as tolerant. Eleven other cultivars showed greater field-susceptibility. The most-susceptible cultivars were Ya Li and Ts'e Li. The third planting, which was managed "organically," was set at a different University farm. Trees there were precocious and productive. A high percentage of marketable fruit was picked from that planting over a 4-year period. Fireblight damage in this planting was low, despite its "organic" production. Limited damage was attributed to early bloom date, ground cover management, and a lack of insect vectors to transmit the bacteria. Hosui, Seuri and Ts'e Li produced large-sized fruit. Shinko, 20th Century, Ya Li and Shinseiki fruit were too small to be marketable without heavy hand-thinning. Asian pears are an interesting alternative crop which are suited to direct-market enterprises or to specialty growers interested in producing organic fruit in the mid-Atlantic region.

577

Effect of Hedging Interval on Yield of 'Chandler' Walnuts

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In many California orchards, expected yields of hedgerow plantings of 'Chandler' (*Juglans regia*) walnuts have fallen below grower expectations. This study compared crop yields following 2-, 3-, and 4-year hedging intervals. Results indicate an incremental yield increase when 'Chandler' trees are hedged on a 3-year rather than the standard alternate-year hedging rotation. Extending the hedging interval beyond 3 years shows little advantage and possible long-term negative consequences as a result of prolonged shading and loss of spurs in the interior canopy.

578

Canopy Manipulation to Enhance Early Season Cropping of 'Arkin' Carambola in South Florida

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Carambola (*Averrhoa carambola* L.) is a fruit tree that exhibits nearly year-round flowering and fruiting in its natural, tropical habitat. The carambola industry of subtropical south Florida is based almost exclusively on the local cultivar Arkin. 'Arkin' is susceptible to harsh winter conditions, which debilitate canopy growth and limit the harvest season to about 7 months (July to February). Crop value increases up to eight-fold during times of scarce production. Less than 10% of total crop volume is produced when fruit value is highest. Strategies to enhance

early season cropping of 'Arkin' carambola were evaluated during a 3-year period. Under favorable growth conditions, carambola trees readily initiate flowers throughout most of the canopy. Pruning 3- to 4-year-old branches to their main axes (branch length was reduced to about one-half of original size) during early spring caused abundant and synchronous flower initiation on pruned branches, and produced a crop in late June-early July. Fruit from pruned branches had excellent appearance due to lack of wind damage. Fruit from intact portions of the canopy began to be harvested 3 to 4 weeks later. In 9-year-old trees, the fall crop was manually shaken off the tree in November-December, when most fruits were about 50% of their final size. Crop removal resulted in abundant flowering (more than three-fold compared to trees which retained their fruit until harvest) throughout the canopy during early spring and also produced an early crop ((48 kg/tree) in early July. Carambola growers in south Florida have begun to adopt selective pruning and fall crop sacrifice to increase economic returns of their groves.

141 ORAL SESSION 37 (Abstr. 579–587)

Fruits/Nuts—Nutrition/Water Management/Temperature Stress

579

Monitoring Nitrates in Ground Water of an Apple Orchard

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Nitrate (NO₃⁻) pollution is of high interest in modern agriculture. Although the amount of nitrogen (N) usually supplied to an apple orchard is lower than other crops, it could become a factor of pollution because of the lower tree root density and of the low nitrogen use efficiency. In this study we monitored the concentration of nitrate in soil water solution in a 3-year old apple orchard located near Grand Rapids (Mich.) during 1996 and 1997. The orchard had no history of fertilization, but alfalfa crop was previously planted for several years. Eight lysimeters, 1.8 m tall and 1.8 m of diameter, were installed in 1995 in the orchard site without changing the soil profile. One tree was planted in each lysimeter in spring 1996. Leached soil solution was collected bi-weekly in a connected 143-L storage container. Additionally, three soil suction tubes (SST) were placed inside and outside the lysimeters at a depth of 0.6, 1.05 and 1.55 m, in order to collect water solution to evaluate the level of nitrate at different soil layers. Daily water (L/ha) and nitrate (kg/ha) flow rate were linearly correlated with an R² of 0.9. Nitrate flow rates were highest and during the wet spring and winter periods. The variation of NO₃⁻ flow rate during the year is a result of root and bacteria activity. All year long, the nitrate concentration in the SST inside the lysimeters was higher than those outside. These results show that the application rate for N could be different from orchard to orchard and it must be necessary to know the soil N background, cropping history and N-NO₃⁻ availability, in order to maximize productivity and avoid environmental risks.

580

Effects of Nitrogen Cut-off Date in Combination with Urea or Abscisic Acid (ABA) on Terminal Bud Set, Defoliation, Cold Acclimation, and Reserve Nitrogen in 'Gala' Apple Nursery Stock

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Bench-grafted 'Gala'/M26 apple trees were grown in pots and fertigated weekly with 150 ppm N starting from 10 May. N supply was terminated on 21 Aug., 18 Sept., and 9 Oct. for the early, mid, and late N cut-off treatment, respectively. Half of the trees in the early N cut-off treatment were sprayed twice with 3% urea at 6-day intervals in early October. Half of the trees in the mid and late N cut-off treatment were sprayed twice with 1000 ppm ABA at 5-day intervals in early and mid-October, respectively. Early N cut-off significantly enhanced terminal bud set, defoliation, and induction of cold acclimation compared to the late N cut-off. Foliar urea increased the reserve N level in all tissues of the early N cut-off trees, almost to the level of late N cut-off trees. Soluble protein concentrations were increased by foliar urea, which accounted for about 23%, 10%, and 17% of the increase in

the total N concentration in bark, wood, and roots, respectively. ABA treatment enhanced leaf senescence and N mobilization in the mid and late N cut-off trees, but did not affect terminal bud set and cold hardiness.

581

Foliar Urea Can Supplement Soil-applied Fertilizer in an Early Maturing Peach

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Despite early studies that suggested foliar urea was ineffective in supplying nitrogen to peach trees, recent studies have shown rapid uptake of low biuret urea by peach leaves and subsequent mobilization to perennial tree parts. Labeled nitrogen experiments have demonstrated the distribution of N among organs to be very similar whether the N is supplied from foliar urea or from soil-applied fertilizer. However, questions still remain concerning the long-term productivity of trees treated repeatedly with foliar urea. Our first experiment was conducted on an early ripening peach, which generally requires about 100 kg N/ha applied to the soil. The treatment to replace all soil applied N with two or three foliar applications of urea in the fall resulted in similar N distribution throughout the tree and equal vegetative growth. However, fruit size was consistently smaller than the soil-fertilized control over a 3-year period. Our second experiment, conducted on the same variety, imposed a treatment to supplement about half the soil applied fertilizer with fall foliar urea applications. This treatment was able to maintain fruit size and yield over a 2-year period. Furthermore, vegetative growth was reduced compared to the soil-fertilized control, suggesting foliar urea may be a useful tool to help manipulate the distribution of growth between reproductive and vegetative processes.

582

Influence of Nitrogen Fertilization on Pecan Nut Quality and Yield

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The influence of various nitrogen fertilization rates on the marketable yield and nut quality of 12-year-old grafted 'Desirable', 'Pawnee', and 'Stuart' pecans in east Texas was investigated. Pecans are alternate-bearing, and this test was conducted during a high-yielding season. Terminal shoot growth and change in trunk diameter was measured to determine tree response to nitrogen rates. A standard rate of 44 kg N/ha was applied in March, April, and May to the control trees as NH_4NO_3 . A second treatment used 112 kg N/ha in March and the standard rates the next two applications. A third treatment used 112 kg N/ha in March and April and the standard rate in May. The fourth treatment used 112 kg N/ha in all three applications. The treatments were arranged in a randomized block design. Nut yields were generally higher with the increase in nitrogen for all cultivars with the exception of 'Stuart', which showed the least change. Highest yield, terminal and trunk diameter growth, and nut quality was obtained with the 336 kg N/ha rate. Some differences in percent kernel, marketable yield and nut size were measured with the three cultivars. Our data indicates that during a high-yielding crop load on young trees, nitrogen fertilization can make a significant difference in yield.

583

Effect of Fall/Winter Application of Foliar Urea on Flowering and Yield of 'Nour' Clementine Mandarin

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Experiments were established using clementine (*Citrus reticulata* Blanco) groves to evaluate effect of urea application (at 0%, 0.8%, and 1.6%) during the period from October to February on flowering and yield. Urea significantly promoted flowering when applied during the period from the end of December to early February. October treatment had no effect, but November treatments somewhat increased inflorescence numbers. "Off year" trees (i.e., trees that have a small fruit load resulting from the previous spring flowering) produced more inflorescence than "on year" trees (i.e., trees with heavy fruit load from flowering of the previous spring), and urea enhanced flowering on both tree types. Flower number per inflorescence increased significantly more on "on year" trees irrespective of the type of inflorescence. Fruit set was significantly increased for trees

receiving urea treatments from November on, with the greatest increase observed for the December/January treatments. Fruit size was increased significantly more by the January treatment than for the December application, whereas the October and November treatment had no effect on these parameters. Consequently, both earliness and export yield were improved with urea.

584

Fertigations and Foliar Sprays with Potassium Increase Fruit Size of Grapefruit

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A study was conducted in a mature 'Ray Ruby' grapefruit (*Citrus paradisi*, Macf.) orchard to elucidate the effect of fertigations and foliar sprays with KNO_3 on fruit size, leaf and fruit K level, and tree growth. The treatments include: 1) Control–no K applied; fertigations applied in 2) December–April (F1); 3) February–May (F2); 4) May–August (F3); 3 times foliar sprays applied at monthly intervals in 5) January–March (S1); 6) April–June (S2); or 7) June–August (S3). Potassium was injected into microsprayer irrigation lines at the annual rate of 440 g K/tree and foliar sprays were applied at 5% concentration. Compared to the control, the S2 and F2 treatments increased the yield of large fruit, i.e., in commercial sizes 48 and larger, by 59% and 41%, respectively. Fruits this large are marketed fresh and thus provide much higher returns to growers than those realizable from sales of smaller fruit destined for processing. Potassium applications in April and May were most effective in increasing fruit growth. The observed increases in yield of large fruit were caused by a shift in the number of fruit from small to large fruit size categories. This conclusion was supported by the observation that a total fruit number and yield per tree were not affected by the treatments. There was a positive relationship between fruit but not leaf K concentrations measured in May and fruit size. No preference was established between expressing leaf and fruit K concentrations on a dry- vs. fresh-weight basis.

585

Effects of Drought and Elevated Soil Temperature on Apple Root Lifespan

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Root lifespan has important consequences for plant growth and productivity, plant competition, and nutrient cycling. However, compared to aboveground parts, much less is known about root systems. Root dynamics of 'Red Chief' Delicious on M26 rootstock trained on a trellis were examined near State College, Pa., using minirhizotrons. Soil was heated 5 °C above ambient at a depth of 5 cm by circulating hot water over a stainless steel grid on the soil surface. Soil temperature (by thermocouples) and soil moisture (by TDR) were monitored to a depth of 1 m. Root birth rate peaked between late May and mid-June, during a period of rapid shoot elongation and fruit expansion. Death rate was highest in July. There was no evidence of alternate growth between roots and shoots. Drought and elevated soil temperature increased root mortality. Median lifespan of fine roots near the soil surface (<20 cm) was least in the heated-drought treatment (30 d) and longest in the unheated-irrigated treatment (56 d). Heating caused substantial increases in root birth rate, thus, causing higher populations in the heated than unheated treatments despite the increased root death rate in the heated soil.

586

Evapotranspiration Measurement and Irrigation Scheduling for Several Tropical Fruit Crops Using the EnviroScan System

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In southern Florida, most tropical fruit crops between Biscayne and Everglades National Parks are irrigated at rates and frequencies based on experience and observations of tree growth and fruit yield rather than on reliable quantitative information of actual water use. This approach suggests that irrigation rates may be excessive and could lead to leaching of agricultural chemicals into the groundwater in this environmentally sensitive area. Therefore, a study is being conducted to increase water use efficiency and optimize irrigation by accurately scheduling irrigation using a very effective management tool (EnviroScan, Sentek Environmental Innovations, Pty., Kent, Australia) that continuously monitors soil water content with highly accurate capacitance multi-sensor probes installed at

several depths within the soil profile. The system measures crop water use by monitoring soil water depletion rates and allows the maintenance of soil water content within the optimum range (below field capacity and well above the onset of plant water stress). The study is being conducted in growers' orchards with three tropical fruit crops (avocado, carambola, and 'Tahiti' lime) to facilitate rapid adoption and utilization of research results.

587

Effect of pH and NH_4NO_3 as a Spray Additive on Penetration of NAA Through Isolated Tomato Fruit Cuticle

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We have reported that NH_4NO_3 (AN, 8 mM, pH 4.2), applied as simulated spray droplets, enhanced penetration of ^{14}C -NAA through isolated leaf and fruit cuticles. One explanation for this response is that AN depresses NAA ($\text{pK}_a = 4.2$) dissociation, increasing the nondissociated moiety, which penetrates more readily than the anion (NAA). Direct measurement of AN (concn. 0-800 mM) effect on NAA (215 μM) dissociation as indexed by change in solution pH revealed no significant effect, with a pH change from 4.19 to 4.05. This change is not sufficient to account for the observed enhancement. When ^{14}C -NAA, buffered (20 mM sodium citrate) at pH 3.2, 4.2, 5.2, 6.2, was partitioned against chloroform, there was a marked increase in NAA partitioning into chloroform as pH was decreased. AN (8 mM) did not alter this partition behavior, also indicating no effect on NAA dissociation. However, in cuticle penetration studies, using a finite dose system with ^{14}C -NAA buffered at pH 3.2, 4.2, 5.2, 6.2, and in the presence and absence of 8 mM AN, there was no marked or consistent pH or AN (-70 to +232% of no AN control) effect on penetration as indexed by initial slope (4-12 h) or penetration after 120 h. The possible effects of AN and buffer on penetration of ^{14}C -NAA from the droplet deposit will be discussed.

142 ORAL SESSION 38 (Abstr. 588-594) Vegetable Crops—Culture & Management

588

Coconut Coir Medium for Tomato Transplant Production

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Peat [70% peat + 30% vermiculite (v/v)] has long been the primary growing medium in standard vegetable transplant production. However, interest has increased in the use of coir (coconut pith) as an alternative vegetable transplant medium because of favorable physico-chemical properties such as high water holding capacity, low bulk density and high potassium content. Sixteen different transplant media formulations (v/v) were tested in a mixture component experiment with tomato, using coir and peat as organic components and vermiculite and perlite as inorganic components. Transplant growth was evaluated after 4, 5, and 6 weeks by growth analysis and at 6 weeks transplant quality parameters (e.g. shoot/root dry weight, leaf area, stem diameter, height, etc.) were collected. Coir grown tomato plants showed a delay in leaf production exhibiting lower leaf area values over the total transplant growth period. Shoot and root growth was maximized in media containing peat as the major organic component. However, plants grown in a 50% peat/50% vermiculite medium were too tall for commercial acceptance. Plants grown in all sixteen-transplant media pulled easily. However, medium loss when transplants were pulled was unacceptable in medium high in perlite content (50% by total volume). Coir-medium compared well with the standard peat/vermiculite medium based on the transplant quality parameters of stem diameter, root growth and height when used in the following mixtures: 50% peat/25% coir/25% vermiculite and 50% peat/25% coir/25% perlite.

589

Effect of Red Polyethylene Mulch on Yield of Fresh-market Tomatoes

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Trials were conducted during the spring production seasons of 1995 and 1996 comparing tomato (*Lycopersicon esculentum* Mill.) Production on red

polyethylene mulch with black (standard) polyethylene mulch. 'Colonial' was used in 1995 and 'Mountain Spring' in 1996. In 1995, fruit was harvested as a mixture of color and mature greens while in 1996 fruit were harvested as pinks only. In 1995, mulch color did not affect early, late, or seasonal yields of medium, large, extra-large, or combined grades of fruit. Mulch color also did not affect fruit size or percentage of fruit that were marketable. In 1996, six harvests were made and there were no differences in yield (medium, large, extra-large, or combined grades), fruit weight of percent marketable fruit at each harvest date or for total season. From the results of these studies there was no benefit from using the red mulch, especially since the cost is higher.

590

Picking Regimes Affect Yield, Grade Distribution and Retail Value of Colored Bell Pepper

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The retail value of yellow and red bell peppers is usually three to five times higher than that of the green ones. However, colored bell pepper production in Alabama is presently limited because most growers do not wait the additional 3 to 6 days needed for marketable green pepper to develop color. Hence, drip-irrigated yellow 'Admiral' and 'Goldcoast' and red 'Bell Star' and 'Capsitrano' bell peppers were grown in single row and bare-ground, and harvested as needed between July and October 1997 at the 0/3 (green), 1/3 or 2/3 colored stages. The interaction variety x picking method was not significant ($P > 0.50$). Early (9,136 kg/ha) and total (32,363 kg/ha) yields of green (0/3) peppers were significantly ($P < 0.05$) higher than those of the 1/3 and 2/3 colored ones (5,166 and 27,235 kg/ha, respectively). Higher green yields were mainly due to increased numbers of marketable fruits rather than increased fruit size. The longer the pods stayed on the plants, the more likely was sunscald to occur. Retail values (/ha) for the early fancy grade were \$10,800 and \$20,500 for the green and colored peppers, respectively (using \$2 and \$6/kg, respectively). These results suggest that the present higher retail value of the colored bell peppers off-sets the lower expected yields.

591

Uniformity of Photosynthetic Photon Flux and Growth of 'Poinsett' Cucumber Plants under Metal Halide and Microwave-powered Solar-1000 Lamps

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The uniformity of photosynthetic photon flux (PPF) and vegetative growth of *Cucumis sativa* L. ('Poinsett' cucumber) were examined using growth chambers equipped with either six 400W metal halide (MH) lamps or with a single 1000W microwave-powered (MP) Solar-1000 lamp. PPF levels in the center of each growth chamber were set initially at 500 $\text{mmol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$. Plants were grown in 7.6-cm-diameter white plastic pots filled with a peat-vermiculite mix and fertilized 1-2X daily with complete nutrient solution. Pots were placed at equal distances from one another in 10 columns of six rows each ($n = 60$). Growth measurements were only taken on the center six columns of plants ($n = 36$) with border plants on each side. The uniformity of PPF was greater in the MP than in the MH chamber for both the 36-pot (495.9 ± 3.7 vs. $459.4 \pm 11.5 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, respectively) and for the 60-pot arrangement (489.3 ± 3.3 vs. $496.6 \pm 9.6 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, respectively). However, growth measurements showed greater uniformity in the MH than in the MP chamber, e.g., 492.2 ± 8.9 vs. 629.9 ± 12.7 mg dry weight of tops. Plants grown for 14 days under MP lamps had significantly greater leaf number, stem and petiole elongation, leaf expansion, and biomass of leaves, petioles, stems, and roots than those grown under MH lamps. These findings demonstrate the efficacy of using MP lamps for increasing seedling production and combined with spectroradiometric measurements, suggest that additional levels of UV-A (320-400 nm) radiation and/or reduced red and far-red radiation may be needed to provide the most compact seedlings when using these lamps. These results should be of interest to growers and researchers involved in protected cultivation. These new MP lamps should also afford a useful tool for photobiologists interested in studying the photocontrol of stem and petiole elongation.

592

Effect of Photosensitive Plastic Films on the Growth of Bell Pepper Transplants

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Removing far-red (FR) light from the greenhouse environment with liquid copper sulfate filters is an effective alternative to application of chemical growth regulators for height control of greenhouse crops. However, liquid filters have limited value in commercial operations because of handling difficulties. In this study, we report the effectiveness of photosensitive plastic films that contain a FR intercepting dyestuff in controlling height of 'Capistrano' bell pepper seedlings. Four types of treatment films, BCE-L (control), YCE-1 #80L, YCE-1 #75L and YCE-1 #65L, with R:FR ratios of 1.2, 1.7, 2.3 and 3.7, respectively, and one 4% liquid copper sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) filter with R:FR of 3.5 were used as the covering materials of experimental chambers. Heights of plants grown under YCE-1 #75 or #65 films were $\approx 30\%$ lower than the control plants. YCE-1 #80 film reduced plant height by $\approx 15\%$. Plant height reductions were apparent within 1 to 2 weeks after initiation of the treatments. Plants grown in YCE-1 #75, YCE-1 #65 and CuSO_4 chambers had significantly lower total leaf area, leaf size, and leaf and stem dry weights than those grown in the control chamber. No differences were observed between YCE-1 #80 and control plants. No difference was found in the total chlorophyll concentration and the ratio of chlorophyll *a* to *b* between the treatment and control plants. Results imply that in peppers, a dyestuff concentration that yields a R:FR over 2 was effective in achieving over 30% height control. Although the filters with R:FR ratios higher than 2 were more effective in controlling height and producing compact pepper plants, the reduction in light intensity, or photosynthetic photon flux (PPF) by increasing dyestuff can reduce dry matter accumulation.

593

Brushing and Temperature Control Transplant Growth of Float-irrigated Bell and Jalapeno Pepper

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Experiments were conducted at the North Carolina State Univ. Phytotron facility in late Summer and Fall 1996. Bell and jalapeno pepper were grown in polystyrene flats using continuous float irrigation. Using DIF (the difference between day and night temperatures), three temperature treatments consisting of positive (+DIF), zero (0DIF), and negative (-DIF) DIF were assigned to three growth chambers. DIF treatments were imposed in each chamber for only the first 2 hr after lights were turned on. Half of the plants in each chamber were brushed twice a day. Height was affected by cultivar, brush treatment, DIF treatment, and all combinations of the three treatments at all sampling dates. Jalapeno pepper experienced greater height reductions due to DIF or brushing treatment than bell pepper. Shoot fresh weight was reduced by brushing at all sampling dates, but DIF was less effective. Length of first internode was influenced by brush and DIF treatments, while leaf area was only affected by brush treatment which caused reductions of 13% and 25% in bell and jalapeno pepper, respectively, at 6 weeks after planting. Brushing increased pepper stem diameter. DIF had little effect on stem diameter but in combination with brushing effectively increased stem diameter over both cultivars.

594

Enhancing Early Maturity in Processing Tomatoes with the Use of Ethephon

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Ethephon is a tool that has been widely used to advance maturity in processing tomatoes. However, its use has largely been restricted to mid- or late-season applications, due to concerns about the chemical's stability and resultant phytotoxicity if hot ambient air temperatures occur during or immediately following applications. Four years of tests evaluating decreased rates of ethephon have been conducted in commercial processing tomato fields. Each test included 10–15 early season cultivars. Fruit quality, maturity and yield were evaluated. In all cases, ethephon rates of 1–1.5 pints of product per acre resulted in maturity enhancements of 8–15 days, compared to paired untreated control plots. There were no adverse effects on fruit soluble solids, color or yield. Industry adoption of this technology has provided a tool to increase acreage by spreading production over a longer period of time and maintain harvest schedules that are adversely impacted by cool weather or replanting.

76 COLLOQUIUM 3 (Abstr. 595–598) Human Pathogens and Fresh Produce: Prevention and Damage Control

595

Case Studies in Food-borne Illnesses from Fresh Produce

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Since 1984, the State of Florida has placed additional emphasis on surveillance and investigation of food-borne illnesses. With the enhanced emphasis, several outbreaks associated with emerging pathogens and unusual vehicles have occurred. Among them are three outbreaks involving fresh produce: fresh-squeezed orange juice, fresh raspberries, and mesclun lettuce (also known as baby greens, spring greens). Florida continues to be alert to the ever-increasing possibility of outbreaks from these and other fresh produce sources. There are specific steps that occur when an outbreak of food-borne illness is identified. These involve traceback methods, statistical comparisons, team efforts by county, state, and federal agencies, and even international agencies. This talk will cover the investigations of Salmonella in orange juice and cyclosporiasis in raspberries.

596

Damage Control: Handling CDC and the Media When Your Product is Attacked

David Riggs*; California Strawberry Commission, Watsonville, CA 95077

The California strawberry industry has unfairly suffered through two food safety events in the past 2 years. In June 1996, an outbreak of a parasitic disease, *Cyclospora*, involved consumers in several cities in the United States and Canada. Initial reports linked the disease to consumption of strawberries from California; however, it was later determined that the likely source of the outbreak was raspberries imported from Guatemala. The impact of the initial reports implicating California strawberries was severe and resulted in industry losses of \$20 to \$40 million. In Mar. 1997, children in Michigan became ill from the consumption of frozen strawberries grown in Mexico and processed by a California firm. The incident clearly did not involve fresh strawberries nor California fields. Again, initial reports were not specific and the industry suffered losses estimated at \$15 million. Comments will focus on the California Strawberry Commission's crisis preparedness plan, how the industry responded to these food scares, what the strawberry industry has learned, and the resulting and continuing government response to these events.

597

A Case Study of Salmonellosis Linked to the Consumption of Fresh-market Tomatoes and the Development of a HACCP Program

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Outbreaks of salmonellosis in the United States in 1991 and 1993 were epidemiologically linked to the consumption of raw tomatoes that originated from the same fresh-market tomato packinghouse in both years. This is a case study of the response of public agencies and an industry association to a food safety crisis and the ensuing development, implementation, monitoring, and verification of a HACCP program that was proposed to serve as a model for the fresh-market tomato industry. Challenges faced by regulatory agencies in monitoring the operations of fresh-market fruit and vegetable handling facilities are discussed. Activities of an interagency food safety committee that was formed to deal with crisis management are described. The status of current research by private industry on safety related issues is briefly reviewed.

598

HACCP Principals and Product Operations: What is the Future?

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Food safety has become a major issue for producers and processors of fresh fruit and vegetable products. Although the safety of fresh and pre-cut fruit and vegetables is outstanding, several recent food-borne outbreaks have increased

the public's awareness of microbiological hazards associated with these products. Hazard Analysis Critical Control Point (HACCP) programs are well-established for many food systems. HACCP is a systematic approach to the identification, assessment, and control of hazards associated with the environment in which foods are produced and handled. Fresh and pre-cut produce are ready-to-eat products that do not receive a preservation (heating) treatment like traditional canning or freezing methods. Since there is no microbiological kill step associated with these products, hazards cannot be eliminated. Therefore, it is critical that efforts be focused on minimizing the incidence of food-borne pathogens on fruits and vegetables through the use of good agricultural practices during growing, postharvest handling, storage, and minimal processing. Several sanitation hurdles can be combined in a synergistic effort to control food-borne pathogens. In addition to chlorination, researchers have investigated alternative treatments for sanitation such as ozone, hydrogen peroxide, trisodium phosphate, edible coatings containing antimicrobial agents, irradiation, pulsed light and bacteriocins. Selection of proper oxygen permeable packaging material is also important to prevent anaerobic conditions that may result in growth and toxin production by *Clostridium botulinum*. However, caution is advised when evaluating new sanitation and packaging materials for fresh produce, because the elimination of spoilage microorganisms may result in conditions that favor the growth of surviving pathogens.

28 WORKSHOP 1 (Abstr. 599–605)

The Use of Computer and Internet in Horticultural Research and Teaching

599

The Development of Horticulture Software on Landscape Plants

Gary J. Kling*; Univ. of Illinois, 1201 S. Dorner Dr., Urbana, IL 61801

This presentation will cover some of the major decisions that were made in the development and modification of software to provide horticultural resources for college students and members of the industry. Technological changes have moved the production from video-disc technology to server-based digital formats, CD-ROM, and the World Wide Web. Each of these changes results in a different product suited to different audiences. The current stage of product development will be presented.

600

Yield Mapping and GIS for Root Crops

Bernard Panneton*; Horticultural R&D Centre, Agriculture and Agri-Food Canada, 430 boul. Gouin, St-Jean-sur-Richelieu, Quebec, J3B 3E6 Canada

I will show how yield mapping data, aerial photography data, and other agronomic data (fertility, soil parameters) can be integrated into a Geographical Information System (GIS) and give a "feel" of the value of these tools to look at crop production as a whole. The capability of GIS in handling and displaying several layers of georeferenced data leads naturally to a decisionmaking process quite similar to the one used in traditional photo interpretation of aerial imagery. This approach can be very valuable for farm managers and consultants in crop production.

601

Use of CD-ROMs for Teaching Systemic Botany and Horticultural Production Courses

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Systemic botany often requires the students to visually examine plant materials at different stages of growth and development to determine family characteristics. Fresh plant materials used in these demonstrations are often unavailable to allow the student to review for laboratory examinations. The timing of production courses means that students do not have the chance to see field operations for various crops. CD-ROMs have been developed as an adjunct to lectures to allow students to review and examine material at their own pace in order to better prepare them for examinations.

602

The Use of Websites in Horticultural Classroom Instruction

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The use of WWW for college curricula has proliferated at an exponential rate over the past 3 years. This sudden deluge of information of all types has provided valuable resources for college instruction. The working website has many advantages for students. By dissecting the components, we can, as instructors, increase our effectiveness and ability to provide our students with useful tools for the near future.

603

The Development of ASHS HortBase—A Global Information System

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In 1997, the ASHS Board of Directors established ASHS HortBase as a Standing Committee of the Society. The ASHS HortBase Committee, a six-member Standing Committee and Chair, is charged to implement and maintain ASHS HortBase. The members of the ASHS HortBase Committee will be chair and chair-elect of the three HortBase Task Forces: 1) Finance and Marketing; 2) Standards—authoring, reviewing, and publishing; and 3) Technology. ASHS HortBase is a dispersed, dynamic horticultural information system (network) on the WWW comprised of peer—reviewed, concise, interlinked information modules to meet the information needs of instructors and students, gardeners and growers. A strong advantage and distinguishing characteristic of ASHS HortBase is our dynamic pool of potential authors, reviewers, and users (ASHS Extension, Industry, and Teaching membership) to continually evolve and update the peer-reviewed information in HortBase. We have the scholastic international standing to provide peer review and validation of the information and to recognition to the authors, coupled with the marketing to stimulate wide use of their information modules. ASHS HortBase is a dispersed system (dispersed development and server costs). The "dispersed cost" for information file development and updating and delivery on the respective authors' dispersed servers disperses the major costs of the HortBase information system. Additional information on ASHS HortBase and the papers presented at the 4-h Colloquium on HortBase at ASHS-97 can be found at <http://hortbase@ashs.org> or contact me (greenjl@bcc.orst.edu, phone 541.737.5452, fax 541.737.3479).

604

The Internet—Changing the Way Horticulturists Communicate

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Four key elements in the discipline of horticulture provide a strong incentive to use the Internet for communicating programmatic information. First, a strong visual component characterizes horticultural knowledge and study. Second, the technical and practical element contained in the undergraduate curriculum, which, similar to plant identification, requires that students are presented highly visual information. Third, use of the Internet increases the efficiency and effectiveness of communicating program information and research results. Finally, the issue of content format for some applications precludes the use of any other media. Taken together, the Internet is significantly changing the environment in which horticulturists communicate.

605

Pedigree and Pedigree Import Wizard

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Pedigree for Windows is a user-friendly program that allows the user to trace agronomic characteristics, draw pedigrees, and view images of several fruit crops, including more than 1400 apple, 800 strawberry, 800 almond, 100 blackberry, 80 blueberry, 790 pear, 200 raspberry examples. Pedigree Import Wizard[®] for Windows is an add-on software for users who are interested in importing their research or breeding data records of fruit, flower, and plant characteristics and any related images into Pedigree for Windows. Pedigree for Windows and Pedigree Import Wizard have been designed so that a user familiar with the Windows operating environment should have little need to refer to the documentation provided with the program. Pedigree Import Wizard uses a comma-separated value (csv)

file format under the MS Excel environment. This option allows the user to add or import additional data to the existing database that are already stored in other software such as Lotus, Excel, Access, QuattroPro, WordPerfect, and MS Word tables, etc., as long as they work under the Windows environment. A free demo version of Pedigree and Pedigree Import Wizard for Windows is available from <http://www.pgris.com>.

30 WORKSHOP 3 (Abstr. 606–610)

Current Status of Thinning of Pome and Stone Fruit Crops

606

Physiology of Fruit Set and Abscission

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Thinning, whether mechanical or chemical, prevents the development of some fruits, allowing the remainder to become larger and more marketable. Chemicals used for thinning either prevent fruit set or increase the proportion of fruits that fall in the "June drop"; some, however, are effective even after this drop. The mechanisms involved in blossom thinning are straightforward. Either pollination is prevented, or some of the flowers are injured, causing their abscission. The mechanisms involved in fruit thinning are more complex; physiologists continue to debate the effects of thinning agents on phloem transport, endogenous hormone content/production, seed development, and other physiological processes. The effects of ethephon in thinning have led to the suggestion that the response to applied hormones is mediated by their effects in stimulating ethylene biosynthesis. Hypotheses as the mechanisms of action of thinning agents will be reviewed, emphasizing those most often invoked today.

607

Blossom Thinning in Pome and Stone Fruit

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Early thinning of apples is important because of its impact on fruit size and next season's flower bud initiation. In the past, apple cultivars were often sprayed with the blossom thinner sodium dinitro-ortho-cresol (Elgetol) during full bloom, followed by a post-bloom application of a fruit thinner such as carbaryl with or without naphthalene acetic acid (NAA). Elgetol was removed from the market in 1989 because of the high cost of re-registration. Full-bloom sprays of sulfurcarbamide (Wilthin), pelargonic acid (Thinex), and endothalic acid (Endothal), ammonium thiosulfate (ATS) or petal fall spray of carbaryl (Sevin XLR Plus) were developed as replacements for Elgetol. Hydrogen cyanamide (HC) and other chemicals have been used to eliminate or to reduce chilling requirements of peaches grown under the warm desert conditions. HC applied at "pink bloom" stage was observed to reduce the number of open blooms in 'Florida Prince' peach; therefore, it was first used for blossom thinning in this cultivar in Arizona. Later, HC was also found to be an effective blossom thinner for plums in Idaho. HC has recently been found to effectively thin apple and peach blossoms. Armothin has also been an effective blossom thinner for peach in California.

608

Chemicals, Timing, and Environmental Factors Involved in Thinner Efficacy

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Chemical thinning of apples may be done over a 3- to 4-week period, starting at bloom and extending through the time fruit are 20 mm or larger in diameter. Potentially useful thinners at bloom include ammonium thiosulfate, Wilthin, endothal, and pelargonic acid. These thinners reduce set by preventing pollination, inhibiting pollen germination, or slowing pollen tube growth. Ethephon can be an effective thinner at bloom, but it is erratic. Petal fall application of thinners has become widely adopted by the industry, primarily because it reduces risks associated with one time thinner application, routinely done in the past. Carbaryl is often the thinner of choice at this time, but where more aggressive thinning is desired, NAA is used either alone or in combinations with carbaryl. Naphthalene-

acetamide is effective when used at bloom but it less frequently used. Apple fruitlets are very vulnerable to the stress imposed by chemical thinners at the 8- to 12-mm stage of fruit development. NAA and Accel are particularly effective at this time, but carbaryl is frequently used because of its mild thinning action and its ability to reduce clustered spurs to one fruit. Unless weather conditions after bloom have been cool, effective thinning after the 18-mm stage of fruit development is less effective. Although erratic, ethephon is the most effective thinner on large fruit. Warm temperature during and following thinner application favor thinner uptake and response. Longer spray drying times favor thinner uptake into the plant. Environmental influences and interactions influencing thinning will be discussed.

609

Spray Volume, Canopy Density, and Other Factors Involved in Thinner Efficacy

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Historically, most airblast chemical applications to apple orchards used a single "average" water volume, resulting in variability of coverage with tree size and also the greatest variable in chemical thinning. This coverage variability can be eliminated by properly quantifying the tree canopy, as tree row volume (TRV), and relating that volume to airblast water rate for adequate coverage. Maximum typical tree height, cross-row limb spread, and between-row spacing are used to quantify the TRV. Further refinement is achieved by adjusting the water volume for tree canopy density. The North Carolina TRV model allows a density adjustment from 0.7 gal/1000 ft³ of TRV for young, very open tree canopies to 1.0 gal/1000 ft³ of TRV for large, thick tree canopies to deliver a full dilute application for maximum water application (to the point of run-off). Most dilute pesticide applications use 70% of full dilute to approach the point of drip (pesticide dilute) to not waste chemicals and reduce non-target environmental exposure. From the "chemical load" (i.e., lb/acre) calculated for the pesticide dilute application, the proper chemical load for lower (concentrate) water volumes can be accurately determined. Another significant source of variability is thinner application response is spray distribution to various areas of the tree. This variability is related to tree configuration, light, levels, fruit set, and natural thinning vs. the need for chemical thinning. Required water delivery patterns are a function of tree size, form, spacing, and density, as well as sprayer design (no. of nozzles and fan size). The TRV model, density adjustments, and nozzle patterns to effectively hit the target for uniform crop load will be addressed.

610

Experience with Thinning: What Factors Contribute to Contradicting Results?

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Results from chemical thinning trials often vary with location/researcher and from year to year within a location. Factors influencing both sources of variation will be discussed. For help explain seasonal variation, the effects of fruit size and temperature will be discussed. A multiple regression model was developed indicating that the degree of fruit thinning is influenced by the interaction of temperature two days after treatment and fruit diameter at the time of treatment. Factors contributing to contradicting results between experiments/researcher include application techniques, types of data collected, differences in experimental designs and sampling techniques, statistical analyses, and potential differences in the tree condition at the time of thinning applications.

38 WORKSHOP 4 (Abstr. 141)

Techniques of Soil Water Measurement

611

Soil Water Measurement as Basis to Optimize Irrigation Scheduling: A Review

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Supplemental irrigation is often necessary for high economic returns for most cropping conditions even in humid areas. As irrigation costs continue to

increase more efforts should be exerted to minimize these costs. Real time estimation and/or measurement of available soil water content in the crop root zone is one of the several methods used to help growers in making the right decision regarding timing and quantity of irrigation. The gravimetric method of soil water content determination is laborious and doesn't suite for frequent sampling from the same location because it requires destructive soil sampling. Tensiometers, which measure soil water potential that can be converted into soil water content using soil moisture release curves, have been used for irrigation scheduling. However, in extreme sandy soils the working interval of tensiometer is reduced, hence it may be difficult to detect small changes in soil moisture content. Capacitance probes which operate on the principle of apparent dielectric constant of the soil-water-air mixture are extremely sensitive to small changes in the soil water content at short time intervals. These probes can be placed at various depths within and below the effective rooting depth for a real time monitoring of the water content. Based on this continuous monitoring of the soil water content, irrigation is scheduled to replenish the water deficit within the rooting depth while leaching below the root zone is minimized. These are important management practices aimed to increase irrigation efficiency, and nutrient uptake efficiency for optimal crop production, while minimizing the impact of agricultural non-point source pollutants on the groundwater quality.

51 WORKSHOP 8 (Abstr. 612–614) Exploring Research Methodologies in Human Issues in Horticulture

612 Conducting Quality Survey Research in Horticulture

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Survey research is an important methodology for many horticultural science professionals. The need to describe, validate, or determine perceptions of various aspects of the field is necessary in order to look at the "big picture" associated with the horticultural profession. When survey research is conducted, several potential errors may occur that become threats to the external validity of the research. This presentation will address the common sources of error in survey research that should be addressed by the researcher and methods used to control each source of error. While quantitative survey methodology will be emphasized in the presentation, qualitative research methodology will also be addressed.

613 The Use and Adaptation of Existing Measurement Tools in People-Plant Research.

*Carol S. Dawson** and *J.M. Zajicek*; Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133

Measurement of variables in physical science research is usually accomplished through the use of mechanical instruments, e.g., rulers, thermometers. The study of the effects of various horticultural activities on people often requires the measurement of mental constructs such as attitudes, opinions, and psychological characteristics. However, the measurement of these variables is not straight-forward. Fortunately, many measurement instruments have already been developed and tested by psychologists and educators which measure variables of interest to researchers studying human issues in horticulture. This workshop will review the types of instruments available and will focus on measures of environmental attitude, and psychological profiles. Criteria for selecting instruments appropriate to specific populations will be discussed. Finally, suggestions for integrating the results of these measures into a human issues in horticulture study will be given.

614 Designing and Evaluating Survey Instruments for Research in Human Issues in Horticulture

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Survey research has a long precedence of use in the social sciences. With

a growing interest in the area of social science research in horticulture, survey methodology needs to be explored. In order to conduct proper and accurate survey research, a valid and reliable instrument must be used. In many cases, however, an existing measurement tool that is designed for specific research variables is unavailable thus, an understanding of how to design and evaluate a survey instrument is necessary. Currently, there are no guidelines in horticulture research for developing survey instruments for use with human subjects. This presents a problem when attempting to compare and reference similar research. This workshop will explore the methodology involved in preparing a survey instrument; topics covered will include defining objectives for the survey, constructing questions, pilot testing the survey, and obtaining reliability and validity information. In addition to these topics some examples will be provided which will illustrate how to complete these steps. At the conclusion of this session a discussion will be initiated for others to share information and experiences dealing with creating survey instruments.

53 WORKSHOP 9 (Abstr. 615) Application of Photoperiodism in Floriculture Crop Production

615 Application of Photoperiodic Manipulation in Vegetative Specialty Floral Crop Propagation and Flowering

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Photoperiod requirements are important for optimum flower development, decreasing production time, year-round flowering, and/or for increasing vegetative growth necessary in stock plant production. The photoperiodic responses were determined for 24 vegetatively propagated specialty floral crops. Each plant species was grown at 8-, 10-, 12-, 14-, and 16-h photoperiods. Photoperiods were provided by 8 h of sunlight, then pulling black cloth and providing daylength extension with incandescent bulbs. Data collected included time to flower, flower number, and vegetative characteristics. *Evolvulus nuttallianus* 'Blue Daze', *Heliotropium arborescens* 'Fragrant Delight', and *Orthosiphon stamineus* 'Lavender' were facultative short-day plants with respect to flowering. Time to flower increased as photoperiod increased. *Duranta repens* 'Blue', *Verbena hybrid* 'Tapien Lavender', and *Verbena peruviana* 'Trailing Katie' were facultative long day plants with respect to flowering. Days to visible bud and first open flower decreased as photoperiod increased. *Argeranthemum frutescens* 'Sugar Baby', *Scaevola aemula* 'Fancy Fan Falls', and *Portulaca hybrid* 'Apricot' had increased flower number as photoperiod increased from 8- to 16- h, although time to first flower initiation was not affected. *Abutilon hybrid* 'Apricot', *Duranta repens* 'Blue', *Evolvulus nuttallianus* 'Blue Daze', *Lotus berthelotii* 'Parrot's Beak', *Lysimachia nummularia* 'Aurea Creeping Golden', *Rhodanthe anthemoides* 'Milkyway', and *Scaevola aemula* 'Fancy Fan Falls' had increased vegetative growth as photoperiod increased. All other species studied were day-neutral with regard to flowering and vegetative parameters.

62 WORKSHOP 11 (Abstr. 616–617) The Riddle of Regular Cropping: The Case for Hormones, Nutrition, Exogenous Bioregulators, and Environmental Factors

616 The Effects of Exogenous Bioregulators and Environment on Regular Cropping of Apple

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Use of exogenous bioregulators ("hormones") to adjust crop load in apple remains challenging to both researchers and producers. These hormones are

sensitive to the rate and timing of application, to the physiological status of the tree, the choice of orchard system, variety and rootstock, and a myriad of cultural practices and environmental factors. All classes of plant bioregulators have been used over the past 30 to 40 years as chemical thinning materials. Most of the standard postbloom thinning programs involve application of a synthetic auxin, such as naphthalene acetic acid (NAA) in combination with carbaryl, a commonly used insecticide. The mode of action of these two compounds is not clearly understood. Gibberellins generally have not been effective thinning materials because of the negative impact on return bloom. Ethylene-releasing compounds have been used successfully as postbloom thinning materials. And cytokinins, particularly synthetic sources such as 6-BA, have been shown to effectively thin fruit and to enhance fruit size on many commercial varieties. The rate and timing of 6-BA applications are particularly critical to obtain the desirable thinning and size responses. Overall, these bioregulators are sensitive to temperature. The use of bloom thinning compounds and their efficacy in the Pacific Northwest will be discussed in the context of return bloom.

617

Effects of Nutritional Factors on Regular Cropping of Apple

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Any mineral nutrient deficiency or toxicity that adversely influences the normal biochemical and physiological processes in the tree can be expected to impact regularity of cropping. Deficiency of N limits growth and flowering of young trees and increases potential for biennial bearing in mature trees while excess N may stimulate excessive vegetative growth that results in shading of spurs and development of weak flowers with reduced set potential. B, Zn, and Cu shortages influence regularity of cropping through effects on flower development, pollination and/or fertilization. Effects of K, Mg, Mn, Fe, or S appear to be indirect, principally as consequences of limited carbohydrate production/availability. Crop load/vegetative growth relationships in one season can exert significant influences on nutrient status within the tree that may influence potential for cropping in the next season. Environmental stress may limit nutrient availability of various nutrient elements at critical times during the flower development and fruit setting sequence. Effects of nutritional factors on regularity of cropping must be considered in relation to their interaction with all other components of the fruit production system. Maintaining appropriate essential mineral nutrient supply and availability to avoid potential deficiencies or toxicities is critical to regular cropping of apple trees.

79 WORKSHOP 14 (Abstr. 618–619) Laboratory Techniques for Teaching Plant Breeding

618

Laboratory Exercise on the Segregation of Flower Color and Related Genes Using *Salpiglossis sinuata*

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Velvet flower (*Salpiglossis sinuata*, Solanaceae) can be used as an excellent demonstration plant for horticultural crop breeding classes. *Salpiglossis* produces large trumpet-like flowers exhibiting an assortment of corolla color and pigmentation pattern. The pistil is large (3 to 4 cm long) with a sticky stigmatic tip and anthers can be easily emasculated prior to anthesis. The large pollen grains are shed in tetrads, which can be separated and individually placed on the stigma. It takes 8 to 9 weeks from seeding to blooming, with a prolific flowering cycle repeated in flushes. Numerous seeds (about 750/capsule) are obtained in 3 weeks after self- or cross-pollination. The influences of three genes that control flower color and pigmentation pattern can be conveniently demonstrated with their dominant and recessive alleles. The *R* gene controls flower color with red (*RR* or *Rr*) being dominant over yellow (*rr*) flower color. The *D* gene controls the density of pigmentation with solid (*DD* or *Dd*) color being dominant over dilute (*dd*) color. Corolla color striping is controlled by the *St* gene with striped (*sts*) being recessive to non-striped (*StSt* or *Stst*) pattern. For example, by using diploid lines of genotypes *RRDD* (red, solid), *RRdd* (red, dilute), or *rrdd* (yellow, dilute) and their crosses, students can easily learn a dominant phenotypic expression in the

*F*₁ hybrid and the digenic 9:3:3:1 segregation ratio in the *F*₂ progeny. Another gene (*C*) that controls flower opening can also be used to show its influence on cleistogamous (closed, self-pollinated, *CC* or *Cc*) versus normal chasmogamous (open-pollinated, *cc*) corolla development. In addition, the induction and use of polyploid (4X, 3X) plants in plant breeding can be effectively demonstrated using this species.

619

Laboratory Techniques for Determining Ploidy Levels

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The determination of ploidy levels is essential for breeding asexually propagated and polyploid crops that may have ploidy chimeras in their tissues or have several polyploid series. This presentation will discuss a laboratory for teaching students how to determine ploidy levels in different plant tissues using different techniques. The different methods for ploidy determination include root tip squashes, pollen mother cell squashes, pollen grain size and germinal pore counts, stomata size and density determination, and gross morphology. After completing these laboratory experiments, students will be able 1) to initiate a study of ploidy determination, 2) to determine the correct course of action in determining ploidy level, and 3) to recognize the various steps required to determine ploidy level in plants.

90 WORKSHOP 17 (Abstr. 620–621) Pollination of Nut Crops: Practice and Problems

620

Hazelnut Pollination

J.L. Olsen*, S.A. Mehlenbacher, and A.N. Azarenko; Oregon State Univ., Dept. of Horticulture, 4017 Ag. & Life Sci., Corvallis, OR 97331-7304

Hazelnuts are wind-pollinated, monoecious, mostly dichogamous, and self-incompatible of the sporophytic type. About 90% of the cultivars studied are proandrous. Anthesis of the pistillate flower is temperature-dependent and occurs from December through February, with its peak in January. Stigmatic surfaces may remain receptive for up to 3 months. Four to 5 months separate pollination and fertilization of the ovule, which usually occurs between mid-May and the end of June in Oregon. A 10% pollinizer density has been the standard, with a recommended distance of <20 m between the main cultivar and the nearest pollinizer. Two or three different pollinizer varieties with different times of pollen shed are recommended. The Oregon hazelnut industry is presently combating the fungal disease, Eastern Filbert Blight, *Anisogramma anomala*. Part of the current management recommendations are to reduce the susceptible pollinizer varieties to a density of around 5%, and then gradually replace those left with immune or more-resistant genotypes. Recent research by S.A. Mehlenbacher refined methods of using fluorescence microscopy to quickly determine genotype compatibility. The self-incompatibility is controlled by a single gene with multiple alleles. The biochemical, physiological, and molecular aspects of sporophytic self-incompatibility are being researched by A.N. Azarenko.

621

Idiosyncrasies of Pecan Pollination

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Pecan orchard productivity and yields often suffer due to pollination problems despite copious pollen produced within or near orchards. The problem is most acute in large block-type orchards of one or two varieties and can be due to pollen not being present at time of stigma receptivity or due to selfing. Fruit-set problems do not appear to be due to excessive pollen on stigmatic surfaces, as is the case in walnut. Pistillate flowers set best when pollen is received within about 1 day after becoming receptive. While stigma receptivity appears to last several days, pistillate flowers usually fail to complete development if pollinated after ≈2 days. Flowering dichogamy of given varieties varies with tree age and spring temperatures, thus often leading to poor pollination and low fruit-set.

Orchards are therefore likely to benefit from the presence of two complementary pollinizers for the main crop variety. Trees in block-type orchards and are beyond about three rows or 50 m from pollinizers are likely to exhibit pollination related yield losses. Many orchards exhibit pollination problems because adherence to the standard two-class Type I/II flowering system often caused planting of non-compatible varieties. A recently developed 30-class Type I/II system allows for greater probability of avoiding pollination problems. Removal of "off-genotype" trees from orchards may reduce yields in block-type orchards.

91 WORKSHOP 18 (Abstr. 622) Improvement and Production of Aromatic and Medicinal Plants

622 Increased Yield and Quality of Herbs Using Plasticulture Systems

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In plasticulture, raised beds, plastic mulch, rowcovers, and fertigation are used to accelerate crop growth and improve crop quality by providing heat, nutrients, and water at near-optimum levels. Because plasticulture is intensive and input costs are high, profits are maximized when high-value crops are grown. For herb crops, plasticulture can also be used to control weeds without herbicides, to prevent soil contamination by rain splashing, and to prevent rooting of side branches. In a studies of *Echinacea* species, root yields in the first year were improved by 35% to 77%. Other crops found to be suitable for plasticulture include feverfew, lemon balm, pineapple sage, valerian, and Chinese licorice. Implementation methods will be described.

104 WORKSHOP 20 (Abstr. 623) Methods of Evaluating Teaching

623 Current Practices in the Evaluation of Teaching in Horticulture

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

Universities offering horticulture curriculum were surveyed for procedures for evaluation of teaching. They were asked to indicate which of the following were used to evaluate instructors: student surveys, peer reviews, administrator reviews, alumni surveys, and others. They were also asked the criteria which were used in these evaluations; i.e., instructor was well-prepared, class presentations were clear and well-organized etc. Many programs used student surveys as the prime means of evaluations of instructors. Some used peer evaluation as well and a few used alumni surveys. Several indicated that they were currently reviewing their process of instructor evaluation.

143 WORKSHOP 27 (Abstr. 624) "What I Did Last Summer"

624 A Mandatory Internship Program at a Land-grant University: The Case of Oklahoma State University

*Brian A. Kahn**; Dept. of Horticulture and Landscape Architecture, Oklahoma State Univ., Stillwater, OK 74078

Internships provide well-documented advantages to students, colleges, and employers. The core requirements in Horticulture and in Turf Management at Oklahoma State Univ. were expanded to include 3 h of credit in an internship

course, effective with the 1991–92 option sheets. All of our departmental teaching faculty advise undergraduate students, and each individual professor supervises the internship experiences of his/her advisees. Coordination is provided by a common syllabus booklet and by leadership from a faculty Undergraduate Horticulture Teaching Coordinator and the Department Head. Outcomes are assessed through student reports, cooperator evaluations, and a formal internship assessment seminar. The mandatory internship has added value to our degrees. Our students graduate with documented work experience in addition to their academic credentials. When our graduates are employed, they tend to more readily adapt to their jobs because they already have been exposed to some of the "real-world" aspects of their profession. This is especially true when an internship experience results in permanent employment with the same firm upon graduation.

144 WORKSHOP 28 (Abstr. 625–628) Patterns and Physiology of Nutrient Use in Horticultural Crops: Implications for Fer- tilizer Efficiency

625 The Regulation of N Uptake at the Whole-plant Level in Tree Crops

*Farbod Youssefi**, *Patrick H. Brown*, and *Steve A. Weinbaum*; Dept. of Pomology, Univ. of California, Davis, CA 95616

Coordinating fertilization practices with tree N uptake is important for reduction of groundwater contamination with nitrate. To reach this goal, the regulation of nitrogen uptake at the whole-plant level must be further understood. A theory that has been proposed on this subject is that a pool of amino-N, whose size is determined by above-ground N demand, cycles in the plant and regulates soil N uptake by exerting an inhibitory effect at the root level. Several experiments were carried out to study this hypothesis in fruit trees. First, foliar applications of N were made in almond trees, which led to the observation that soil N uptake was reduced in treated trees. In these trees, foliar-applied N was present in the roots when uptake was reduced; further, amino-N content of leaf and bark phloem sap was increased after several hours in the treated tree. In another experiment, amino-N content of phloem and xylem sap of almond trees of varying N status was determined. Several trees under each N status were given a pulse of abundant N fertilizer, so that their N uptake would be compared. Trees of higher N status, with greater amounts of amino-N cycling in their sap, did not take up more N than equivalent control plants, whereas lower N status trees did. To complete this series of experiments, it was observed that fruit-bearing shoots in walnut trees exported smaller proportions of foliar-applied N than non-bearing shoots, indicating that above-ground N demand may regulate the pool of N that moves down in the plant. These results and the principles that regulate N uptake will be discussed.

626 Using Nutrient Uptake Patterns to Develop Efficient N Manage- ment Strategies for Vegetables

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Nitrogen in a soil that is not immediately taken up by a crop is subject to leaching, denitrification, and other mechanisms of loss. Generally, split applications of N throughout the growing season reduce the potential for N loss compared to a single preplant application. Timing of N application should account for the characteristic N uptake patterns of the crop and the lag time between application of fertilizers and plant availability. N uptake studies allow one to identify total amount of N accumulated by the crop and periods of peak nitrogen demand. This information can then be used to devise management strategies aimed at supplying N preceding anticipated N uptake. Split sidedress N application, fertigation, and the use of controlled-release fertilizers are all viable options, depending on the crop production scenario and available infrastructure.

627 Properly Timed Foliar Nutrient Applications Provide an Efficient Means to Meet Nutrient Demand to Increase Flowering, Fruit Set, and Size of Citrus and Avocado

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The goal of our research is to identify the role that specific essential nutrient elements play in the physiology of horticultural crops and then to apply the nutrient as a fertilizer to the foliage at key times in the phenology of the tree, i.e., a time when the demand for the nutrient is likely to be high, in order to stimulate a specific physiological process. This approach proved successful in the following completed studies. A single winter prebloom application of nitrogen as low-biuret urea made to the foliage of 30-year-old 'Washington' navel orange (*Citrus sinensis* L. Osbeck) trees at the time of irreversible commitment to flowering significantly increased yield and fruit number per tree for each of three consecutive years. In addition, the number of commercially valuable fruit with diameters of 6.1 to 8.0 cm significantly increased as yield increased ($r^2=0.88$). Applications of boron as sodium tetraborate to the foliage of a commercial orchard of 'Hass' avocado (*Persea americana* Mill.) trees at the cauliflower stage of inflorescence development (gametogenesis) increased the number of pollen tubes reaching the ovule, ovule viability and cumulative yield ($P \leq 0.05$). Additional examples from ongoing research also will be presented.

628

Nutrient-Use Patterns in Nursery Crops

Mary Ann Rose* and Barbara Biernacka*, Dept. of Horticulture and Crop Science, The Ohio State Univ., Columbus, OH 43210

Long-standing fertilizer recommendations for field-grown nursery and landscape ornamentals are based on maximizing growth, not nutrient efficiency. Further, these recommendations fall short because of failure to consider 1) the extent of crop nutrient removal, 2) varying nutrient retention characteristics of soils across the United States, and 3) a body of research that suggests that woody ornamentals have a limited response to fertilization under most soil conditions. Concern for the environmental impact of fertilization justifies a reevaluation of current nursery fertilization practices, as well as a discussion of the practical constraints on the adoption of new approaches, e.g., nutrient demand-driven fertilization. Research on the nutrient use patterns of woody plants will be reviewed with emphasis on implications for increasing fertilization efficiency. OSU research on water availability and nutrient-use interactions also will be presented.

43 POSTER SESSION (Abstr. 629–631) ACB Poster Competition

629

The Growth of New Guinea Impatiens with Controlled-release Fertilizer in a Recirculating Subirrigation System

Daphne Richards* and David Wm. Reed*, Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133

New Guinea impatiens 'Illusion' were grown in a recirculating subirrigation system using a controlled-release complete fertilizer (Osmocote 14–14–14). In a preliminary experiment, plants were grown under varying label rates (0, 0.5x, 1x, 2x, 4x) incorporated throughout the growing medium. Excellent growth and high-quality plants were produced at the 0.5x and 1x rates. Higher rates caused reduced growth and quality. The next study was a factorial experiment of rate (0.25x, 0.5x, 0.75x, and 1x) times placement (incorporated, top dress, bottom placement, and dibble). Slight growth increases and dramatic leaf area increases were observed with increasing fertilizer rate, regardless of placement. Slightly higher fresh and dry weights were observed in the incorporated treatment compared to the top dress treatment. Both the incorporated and top dress treatments yielded better growth than bottom placement or dibble treatments. Other parameters measured (height, chlorophyll content) did not appear to be affected by placement. EC (dS/m) of the growing medium was highest in the top 1/3 of the container in all placement treatments. EC increased with increasing rate. EC was higher in the incorporated than in the top-dress treatment, which may be due to different release rates or may be an artifact of extraction (prill removal). No rates or placements showed damaging EC levels.

630

Effects of Polyethylene Glycol on Development of Grape (*Vitis*

vinifera L. 'Thompson Seedless') Somatic Embryos

Fred K. Westphal* and Michael E. Compton*, School of Agriculture, Univ. of Wisconsin–Platteville, Platteville, WI 53818

Torpedo-stage somatic embryos were selected from actively growing cultures and transferred to embryo maintenance medium [MS with (per liter) 412.5 mg NH_4NO_3 , 475 mg KNO_3 , 1 g *myo*-inositol, 90 g sucrose, 2 g activated charcoal, and 7 g TC agar] supplemented with either 0%, 2.5%, 5%, 7.5%, or 10% polyethylene glycol (PEG) for 4, 8, or 12 weeks. Embryos placed on treatment media were transferred directly to grape somatic embryo germination medium [MS with (per liter) 1 g *myo*-inositol, 30 g sucrose, 1 M benzyladenine, and 7 g TC agar] once their PEG treatment was terminated. The number of embryos that germinated was recorded 4 weeks after transfer to somatic embryo germination medium. The number of germinated embryos that differentiated into plants was recorded at 8 weeks. There was no difference in germination rates and embryo differentiation among embryos incubated on medium with or without PEG for 4 weeks. A difference in embryo growth rate was observed after 8 weeks on medium with PEG. Embryo grew fastest on media containing 5% or 7.5% PEG. In addition, embryos grown on medium with 5% or 7.5% PEG were morphologically similar to zygotic embryos.

631

Effect of C6-Volatiles on Bioluminescent Plant Pathogens

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C6 volatile compounds are known to be produced by the plant upon pathogen attack or other stress-related events. The biological activity of many of these substances is poorly understood, but some might produce signal molecules important in host–pathogen interactions. In this research we explored the possibility that lipid-derived C6 volatiles have a direct effect on bacterial plant pathogens. To this purpose we used a unique tool, a bacterium genetically engineered to bioluminesce. Light-producing genes from a fish-associated bacterium were introduced into *Xanthomonas campestris* pv. *campestris*, enabling nondestructive detection of bacteria in vitro and in the plant with special computer-assisted camera equipment. The effects of different C6 volatiles (*trans*-2 hexanal, *trans*-2 hexen-1-ol and *cis*-3 hexenol) on growth of bioluminescent *Xanthomonas campestris* were investigated. Different volatile concentrations were used. Treatment with *trans*-2 hexanal appeared bactericidal at low concentrations (1% and 10%), while treatments with the other volatiles were not inhibitive to bacterial growth. The implications of these results with respect to practical use of *trans*-2 hexanal in pathogen susceptible and resistant plants will be discussed.

46 ORAL SESSION (Abstr. 632–636)

Collegiate Branch Oral Competition

632

The Effect of Thiols and Rhizopon on the Rooting of Woody Stem Cutting of *Punica granatum* L.

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A research study was established to determine the effect of thiol compounds glutathione (GSH) and dithiothreitol (DTT) to induce rooting and root growth of woody stem cuttings from *Punica granatum* L., either alone or in combination with rhizopon. Woody cuttings of *P. granatum* 10 cm long were collected from 5-year-old potted greenhouse grown plants. No leaves were left attached on the cuttings. The proximal end of cuttings were dipped for 10 sec in 0.05 and 0.1 mM of GSH; 0.6, 1, and 2 mM of DTT followed by a 5-min rest, and immediately dipped in a solution of 1500 ppm of Rhizopon for 10 sec. Untreated cuttings were used as control as well as cuttings dipped only in 1500 ppm of Rhizopon for 10 sec. Rooting was continuous with bottom heating at 24 °C under greenhouse conditions. The experimental data was analyzed statistically using a completely randomized block design with five replications. The average total number of roots was increased when the cuttings were treated with the thiol compounds and Rhizopon, 52 days after treatment. However, DTT at 1.0 mM increased more significantly the average total number of roots than GSH at any concentration. The presence of DTT alone at 1.0 mM or with 1500 ppm of Rhizopon increased

the average number of roots to 10.04 and 10.99, respectively. No significant difference was found for the treatment of 0.05 mM GSH and 1500 ppm Rhizopon showing average number of 12.11 roots. Significant average total root length was detected in cuttings treated with 1500 ppm Rhizopon compared to control, GSH at 0.1 mM, and DTT at 0.6 mM and 1.0 mM.

633

Relationships of Resveratrol, Anthocyanin, and Soluble Solids to Maturity in *Vitis lambrusca*

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Resveratrol in *Vitis vinifera* cultivars has been shown to be important in resistance to infection of *Botrytis cinerea* (gray mold). Also, resveratrol is a constituent of wine that has been shown to confer protection against arteriosclerosis, heart disease, and cancer. The relationship between grape maturity and resveratrol concentration levels, soluble solids, and anthocyanins were examined on *V. lambrusca* cultivars. 'Concord' and 'Catawba' grapes were harvested weekly from August to maturity from a production site in Lexington, Ky. Irradiation and non-irradiation of berries was performed in the laboratory and resveratrol concentration was analyzed. Berry skins were extracted with methanol/water (8:1 v/v) in 10ml/g of fresh weight tissue. Resveratrol was quantified using reverse-phase HPLC. Soluble solids were measured weekly by refractometer, and anthocyanin content was determined by spectrophotometer. Results showed a marked increase in resveratrol concentration as grapes matured, and followed by a subsequent decrease at final harvest. Sugar content increased weekly in each cultivar, and was maximal at final harvest.

634

Optimizing Graft Union Formation between Sweetpotato (*Ipomoea batatas*) and Bush Morning Glory (*Ipomoea carnea* ssp. *fistulosa*) as a Prelude to Chimera Development

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Bush morning glory (*Ipomoea carnea* ssp. *fistulosa*) and ornamental sweetpotato (*Ipomoea batatas* 'Blackie') were grafted using various procedures. Lanolin pastes containing 3% BA, 3% NAA, and a mixture of 3% BA/3% NAA were tested as a means of promoting adventitious shoot development at the graft union. Excellent "take" was obtained with all graft types tested. The growth regulator treatments resulted in marked differences in callus formation at the wounded graft union. Lateral shoot development below the graft union also was affected by the growth regulator treatments. The highest quantity of callus was formed using the mixed paste, while BA enhanced lateral shoot formation below the union. Results indicate that in-vivo grafting of these two species may not be the best procedure for obtaining interspecific chimeras.

635

Cut Flowers Being Sold as Impulse Items: A Look at Factors Affecting Impulse Product Merchandising

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Consumer behavior research seems to play an big role in determining the wants and needs of an industry. This research helps to shape the way we market to the consumers and helps make marketing strategies more effective. In the 1950s grocery stores began to sell horticulture products in order to alleviate the growers' surplus. Supermarkets now have seem to found their niche in this market due to the fact that they can influence their consumers to buy their flowers right along with their bread, and get all of their shopping done at once. This new type of sale, commonly referred to as the impulse sale, can relate directly to how well the store is merchandised and maintained. A study was conducted at a local supermarket, to determine the following: good locations for impulse sales items, special conditions affecting impulse sales items, and what types of things could affect demand for impulse items. It was discovered that certain locations make better sales than other locations. Locations that were front and center and allowed easy access to seeing the mixed flower bouquet without having to touch it yielded the best results. The variables used to show a change in demand showed little to some variability and has raised some questions which may be used to conduct future research.

636

Coordinating Sustainable Landscapes for a Low-income Community

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The City of Clemson, along with the National Wildlife Federation, Habitat for Humanity, and Clemson Univ., recently formed a strategic alliance to incorporate ideas for the landscaping of low-income homes. Their goal was to create an aesthetically pleasing, environmentally responsible design that catered to the future development of the families involved. The low-income housing project was selected as an independent study for Spring 1998. As student project manager I coordinated and documented the project. Objectives of the project were: 1) to promote knowledge and research on environmental issues and culturally diverse populations; 2) to create backyard wildlife habitats and sustainable community environments for low income families; 3) to provide students with the opportunity to learn and mature by participating in a long-term project involving a measurable impact. Project steps included analysis, research, design, planning, scheduling, implementation, and reflection on the impact made by those involved. The City of Clemson, along with the others involved, was delighted to be the first to address the issue of enhancing open space around low-income buildings in addition to landscaping the properties surrounding the homes.